

1
 2
 3
 4
 5
 6
 7
 8
 9
 10
 11
 12
 13
 14
 15
 16
 17
 18
 19
 20
 21
 22
 23
 24
 25
 26
 27
 28
 29
 30
 31
 32
 33
 34
 35
 36
 37
 38
 39
 40
 41
 42
 43
 44
 45
 46
 47
 48
 49
 50
 51
 52
 53
 54
 55
 56
 57
 58
 59
 60
 61
 62
 63
 64
 65
 66
 67
 68
 69
 70
 71
 72
 73
 74
 75
 76
 77
 78
 79
 80
 81
 82
 83
 84
 85
 86
 87
 88
 89
 90
 91
 92
 93
 94
 95
 96
 97
 98
 99
 100
 101
 102
 103
 104
 105
 106
 107
 108
 109
 110
 111
 112
 113
 114
 115
 116
 117
 118
 119
 120
 121
 122
 123
 124
 125
 126
 127
 128
 129
 130
 131
 132
 133
 134
 135
 136
 137
 138
 139
 140
 141
 142
 143
 144
 145
 146
 147
 148
 149
 150
 151
 152
 153
 154
 155
 156
 157
 158
 159
 160
 161
 162
 163
 164
 165
 166
 167
 168
 169
 170
 171
 172
 173
 174
 175
 176
 177
 178
 179
 180
 181
 182
 183
 184
 185
 186
 187
 188
 189
 190
 191
 192
 193
 194
 195
 196
 197
 198
 199
 200
 201
 202
 203
 204
 205
 206
 207
 208
 209
 210
 211
 212
 213
 214
 215
 216
 217
 218
 219
 220
 221
 222
 223
 224
 225
 226
 227
 228
 229
 230
 231
 232
 233
 234
 235
 236
 237
 238
 239
 240
 241
 242
 243
 244
 245
 246
 247
 248
 249
 250
 251
 252
 253
 254
 255
 256
 257
 258
 259
 260
 261
 262
 263
 264
 265
 266
 267
 268
 269
 270
 271
 272
 273
 274
 275
 276
 277
 278
 279
 280
 281
 282
 283
 284
 285
 286
 287
 288
 289
 290
 291
 292
 293
 294
 295
 296
 297
 298
 299
 300
 301
 302
 303
 304
 305
 306
 307
 308
 309
 310
 311
 312
 313
 314
 315
 316
 317
 318
 319
 320
 321
 322
 323
 324
 325
 326
 327
 328
 329
 330
 331
 332
 333
 334
 335
 336
 337
 338
 339
 340
 341
 342
 343
 344
 345
 346
 347
 348
 349
 350
 351
 352
 353
 354
 355
 356
 357
 358
 359
 360
 361
 362
 363
 364
 365
 366
 367
 368
 369
 370
 371
 372
 373
 374
 375
 376
 377
 378
 379
 380
 381
 382
 383
 384
 385
 386
 387
 388
 389
 390
 391
 392
 393
 394
 395
 396
 397
 398
 399
 400
 401
 402
 403
 404
 405
 406
 407
 408
 409
 410
 411
 412
 413
 414
 415
 416
 417
 418
 419
 420
 421
 422
 423
 424
 425
 426
 427
 428
 429
 430
 431
 432
 433
 434
 435
 436
 437
 438
 439
 440
 441
 442
 443
 444
 445
 446
 447
 448
 449
 450
 451
 452
 453
 454
 455
 456
 457
 458
 459
 460
 461
 462
 463
 464
 465
 466
 467
 468
 469
 470
 471
 472
 473
 474
 475
 476
 477
 478
 479
 480
 481
 482
 483
 484
 485
 486
 487
 488
 489
 490
 491
 492
 493
 494
 495
 496
 497
 498
 499
 500
 501
 502
 503
 504
 505
 506
 507
 508
 509
 510
 511
 512
 513
 514
 515
 516
 517
 518
 519
 520
 521
 522
 523
 524
 525

a31188005428954b

NON-CIRCULATING

[illegible]

1875

1875

BULLETINS

FROM

ONTARIO AGRICULTURAL COLLEGE

Nos. 113 TO 133.

AND

SPECIAL BULLETINS

Issued by the Ontario Department of Agriculture.

TORONTO
1904.

CONTENTS.

AGRICULTURAL COLLEGE BULLETINS.

113	Sugar Beet Experiments in Ontario	A. E. Shuttleworth
114	Dairy Dulletin	Dairy School
115	Comparative Values of Ontario Wheat for Breadmaking Purposes	R. Harcourt
	Notes on Varieties of Winter Wheat.....	C. A. Zavitz
116	The Hessian Fly in Ontario	Wm. Lochhead
117	Pasteurization of Milk for Butter-making.....	{ H. H. Dean { F. C. Harrison
118	Yeast and its Household Use	F. C. Harrison
119	Ventilation of Farm Stables and Dwellings.....	J. B. Reynolds
120	Bitter Milk and Cheese	F. C. Harrison
121	Ripening of Cheese in Cold Storage Compared with Ripening in Ordinary Curing Rooms.....	{ H. H. Dean { F. C. Harrison
122	Spray Calendar.....	Wm. Lochhead
123	Cold Storage of Fruit.....	{ J. B. Reynolds { H. L. Hutt
124	Nature Study, or Stories in Agriculture.....	Staff O. A. C.
125	Roup (A Disease of Poultry)	{ F. C. Harrison { H. Streit
126	Peas and the Pea Weevil.....	{ C. A. Zavitz { Wm. Lochhead
127	Farm Poultry.....	W. R. Graham
128	The Weeds of Ontario.....	{ F. C. Harrison { W. Lochhead
129	Bacon Production	G. E. Day
130	Bacterial Content of Cheese Cured at Different Tem- peratures	{ F. C. Harrison { W. T. Connell
131	Ripening of Cheese in Cold Storage Compared with Ripen- ing in Ordinary Curing Rooms.....	{ H. H. Dean { R. Harcourt
132	Roup : An Experimental Study... ..	{ F. C. Harrison { H. Streit
133	Present Condition of San Jose Scale in Ontario.....	Wm. Lochhead.

SPECIAL BULLETINS.

Birds of Ontario in relation to Agriculture ; C. W. NASH.

Winter Treatment and Summer Treatment of San Jose Scale : Report of Commis-
sioners.

How to examine Apiaries and Cure them of Foul Brood : Wm. McEvoy.

B113
ONTARIO AGRICULTURAL COLLEGE

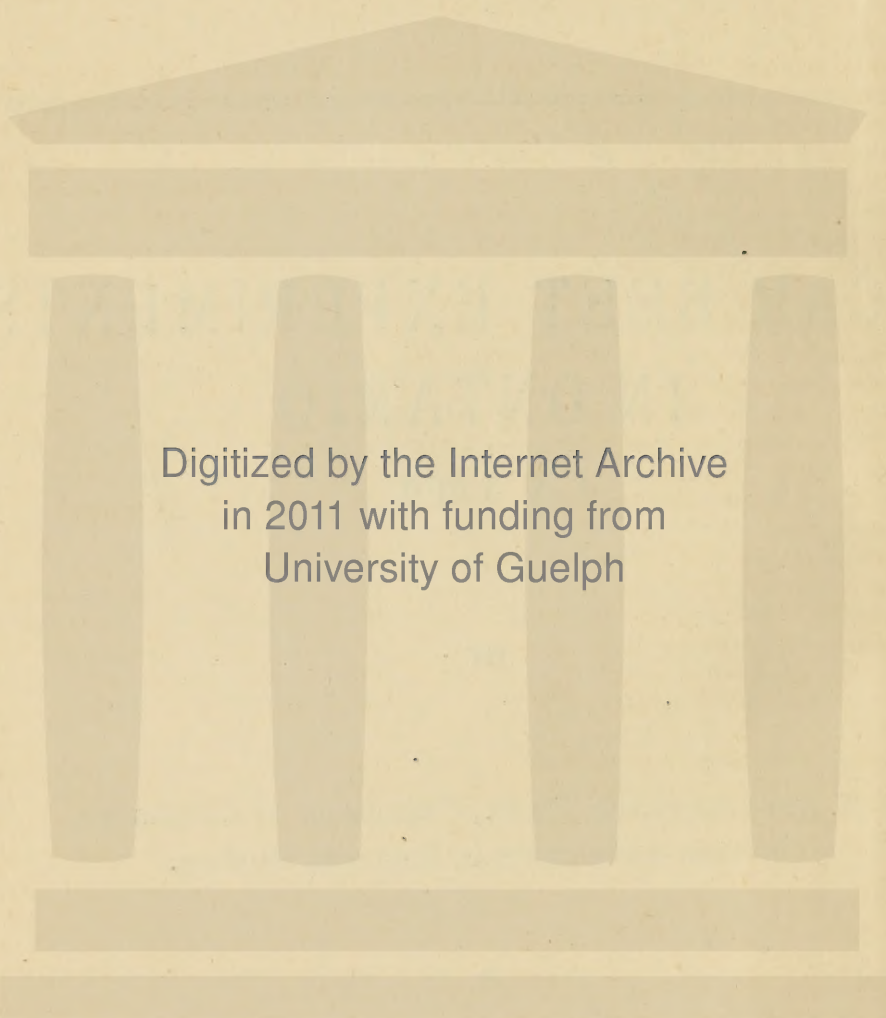
BULLETIN 113.

SUGAR BEET EXPERIMENTS
IN ONTARIO
IN 1900.

BY

A. E. SHUTTLEWORTH, Ph.D., PROFESSOR OF CHEMISTRY,
ONTARIO AGRICULTURAL COLLEGE, GUELPH.

ONTARIO DEPARTMENT OF AGRICULTURE,
TORONTO, ONT., MARCH, 1901.



Digitized by the Internet Archive
in 2011 with funding from
University of Guelph

Ontario Agricultural College and Experimental Farm.

SUGAR BEET EXPERIMENTS IN ONTARIO
IN 1900BY A. E. SHUTTLEWORTH, PH. D., PROF. OF CHEMISTRY, ONTARIO AGRICULTURAL
COLLEGE, GUELPH, ONT.

The beet sugar industry has been before the attention of the people of Ontario for a number of years, during which time sugar beets, in small patches, have been grown probably in every county of the earlier settled portions of the Province. Seed has been received by our farmers either from seed stores or from capitalists or others interested in the establishment of the beet sugar industry in Ontario. It has been planted, and the crop cultivated much as farmers commonly plant and cultivate root crops grown to feed stock. Numerous samples, containing from one to five roots each, have been forwarded to our chemical laboratory and analyzed, the results of which have been published from time to time in our annual reports. In the years 1889, 1890, 1891, 1897 and 1899, 26, 117, 32, 40 and 89 samples of sugar beets respectively were received and analyzed, out of which only 3, 68, 20, 25 and 30 samples, respectively, contained 12 per cent. or over of sugar in beet and co-efficient of purity of 80; or, in other words, 158 samples out of 304, or practically 52 per cent., were too inferior in quality for factory purposes. These inferior results were due entirely to a lack of knowledge on the farmers' part of the conditions of planting, manuring, cultivating, etc., needed to produce both quality of beet and yield.

The object of the sugar beet experiments conducted this year is, first, to ascertain the quality and the yield of beets that may be obtained from our soil under proper conditions of planting, manuring, cultivating, etc., and secondly, to give object lessons in growing sugar beets for factory purposes. My report will show beyond any shadow of doubt that the soil and climate of extensive portions of Ontario are admirably adapted to the growth of sugar beets of high quality and tonnage.

It was in response to numerous and pressing requests that the Hon. John Dryden, Minister of Agriculture, decided to direct that these experiments be conducted. Among the requests was one worthy of special mention. I refer to that of The Canadian Sugar Beet Syndicate, Limited, of Glasgow, Scotland, by whom, through their Secretary, Mr. William James Stewart, proposals were received to furnish free four pounds of beet seed to every one of fifty farmers in the neighborhood of Aylmer, Elgin Co., to every one of fifty farmers in the vicinity of the town of Welland, and to offer to each place six prizes of \$30, \$25, \$20, \$15, \$10 and \$5 in consideration that the parties receiving the seed would plant the same upon one-quarter of an acre and cultivate under the directions of the Ontario Agricultural College. Further, the syndicate proposed giving the sum of \$240 in payment of certain inspection of these beet plots.

The people about Newmarket, York Co., also made application to the Government to have a sugar beet experiment conducted in their section. No other place making application, our sugar beet experiments were confined, therefore, to the above three neighborhoods, namely, Newmarket, Aylmer and Welland.

Messrs. D. H. Price and W. S. Caron, of the town of Aylmer, Elgin Co., early in March last arranged for the appointment of a committee to secure the names of fifty farmers to whom seed would be given conditionally that the directions for cultivation would be closely followed. Receiving advice from the above gentlemen that the names of fifty farmers who desired seed had been secured, I mailed them

on April 12th circular letters of information for distribution among these farmers to direct them in the selection and cultivation of their plots intended for sugar beets.

Mr. A. Griffiths, of the town of Welland, likewise arranged, early in March, for the appointment of a committee to secure the names of fifty farmers to whom seed would be given upon the same conditions as in Aylmer. Word having been received that the names of fifty suitable farmers had been secured, I likewise mailed



Figure 1 is a patch belonging to Mr. D. Cole, Southend P.O., Welland Co., photographed just after thinning, being one month after date of planting.

him, upon the 12th of April, a number of the above circulars, for distribution among the farmers of Welland who were to receive seed.

The seed forwarded by the above Canadian Sugar Syndicate of Glasgow for the experiments in Aylmer and Welland was purchased in Germany, and is the Kleinwanzleber-Elite.

On April 26th I addressed a meeting of the farmers of Aylmer, to whom seed was promised, on the subject "The Cultivation of Sugar Beets," at the close of which the seed, in four pound packages, was distributed. During the following



Figure 2 shows a beet patch belonging to C. E. Lundy, Newmarket P.O., County of York, planted on the 12th of May, and photographed about the 14th of July.

five days every plot was inspected by a competent party to see that each plot selected was suitable and properly cultivated, and that the seed was planted at the time and in the manner required.

In Welland on April 28th, I addressed a similar meeting on the above subject, after which the seed was delivered, the plots inspected, etc., as at Aylmer.

At the time of the above inspection of the plots, a copy of a special bulletin,

entitled "The Cultivation of Sugar Beets," and published by the Ontario Department of Agriculture for the direction of the farmers in these experiments, was given to each farmer with a request to follow closely the directions for cultivation, thinning, etc., therein given.

Following the request from the farmers about Newmarket for a sugar beet experiment, the local member for North York, the Hon. E. J. Davis, Minister of



Figure 3 is a photograph of a plot of beets belonging to C. O. Learn, Aylmer, Elgin Co., which were planted on May 5th and photographed early in July. Mr. Learn, at the time of harvesting his beets early in November writes, "I am very much surprised at the yield. I will have over seven tons from a quarter of an acre." In the background are standing Mr. Learn, with his hand upon a scuffler, and Messrs. Price and Caron, of the town of Aylmer, who strongly believe in the adaptability of our soil and climate to the sugar beet industry.

Crown Lands, arranged for a meeting of the farmers of North York to be held in the town of Newmarket at two o'clock on Wednesday, May 9th. This meeting, called at the request of the people for the purpose of arranging for a sugar beet experiment, was attended by a large body of representative farmers, many of whom, after a full discussion of the subject, volunteered to plant sugar beet seed.

Seed known as the Mangold sugar beet seed, imported from Germany, was im-

mediately distributed in two or four pound lots among forty-five farmers, whose plots were inspected and who received copies of the above bulletin as in the case of those at Aylmer and Welland.

Commencing in Aylmer on May 30th, between this date and June 3rd every plot of beet plants which were at that time ready to thin was inspected in order to insure proper cultivation and thinning at the right time, and to score the plots.



Figure 4 is a photograph of a most magnificent patch of beets belonging to Mr. J. M. Van Patter, Luton P.O., Elgin Co. This photograph shows Mr. Van Patter and three of his bright little boys eagerly waiting for an opportunity to cultivate beets for an Aylmer Sugar Beet Factory. His patch yielded, net weight, 30 tons, 581 lbs. of beets at a cost of \$26.40 per acre.

Scoring consisted in allowing for a perfectly clean patch 5, for a well pulverized surface condition of the soil 5, for an entirely full stand of plants in the rows 5, and for straight rows drilled on the flat exactly twenty-one inches apart 5, making a maximum of 20 marks for this second inspection. The object of scoring was two-fold; first to impress every experimenter with the feeling that he was under obligation to closely follow instructions; secondly, to rank each in view of ascertaining who shall be entitled to prizes.

In the same manner and for the same purpose every patch at Welland and at Newmarket was inspected and scored, the former between May 30th and June 2nd, and the latter between the 8th and 11th of June.

The third inspection of every patch in the above three places was made between August 22nd and September 7th, a time when the ground should be well hidden by the expanding and interlacing foliage, which was then beginning to turn faintly yellow. At this third inspection the beet plots were again scored with the same two-fold object as in the second inspection. Scoring at this time consisted in allowing for a perfectly clear patch 5, for thorough singling, that is, the plants thinned in the row to a distance of 7 inches apart and only one plant in a place, 5; for general appearance, by which is meant a full, thrifty crop covering the ground entirely, 10; making a maximum of 20.

COLLECTING SAMPLES AND ESTIMATING YIELDS.

Five men at Aylmer, five at Welland and four at Newmarket, all of whom had best plots and were so favorably situated that the entire number of plots could be reached in one day, were appointed Assistant-Inspectors to collect samples and to superintend the pulling of beets to estimate yield. Before entering upon their work these Assistant-Inspectors were required to make declaration before a commissioner as a guarantee of honest work and to place them above suspicion. To illustrate, the declaration of Assistant-Inspector Joshua Sisler and Exhibit "A" are here given:

Dominion of Canada, Province of Ontario, County of Elgin, To Wit:	}	In the matter of Sugar Beet Experiments directed by the Ontario Agricultural College during the year 1900.
---	---	--

I, Joshua Sisler, of the Township of Malahide, in the County of Elgin, farmer, do solemnly declare that I will well and faithfully perform the duties of Assistant-Inspector of the said Sugar Beet Experiments as set forth in the paper writing hereto attached marked exhibit "A" to this my declaration, in the manner and form and at the times set forth in the said paper writing, and as more fully explained to me by the director of the said experiments, without favor or partiality to anyone whatever.

And I make this solemn declaration conscientiously believing it to be true, and knowing that it is of the same force and effect as if made under oath and by virtue of "The Canada Evidence Act, 1893."

Declared before me at the Town of Aylmer, in the County of Elgin, this 29th day of Sep- tember, A.D., 1900.	}	(Sgd.) J. SISLER.
(Sgd.) E. A. MILLER, a Commissioner, etc.		

EXHIBIT "A"

ONTARIO AGRICULTURAL COLLEGE.

GUELPH, ONT., September 15th, 1900.

DEAR SIR,—Enclosed please find a list of ten names of farmers who are growing sugar beets, and from whom we want samples of beets for chemical analysis. You will also find enclosed a bunch of labels and a form for making declaration, after which please return the same to me as a guarantee that you will collect samples of beets without favor to anyone. I want the first sample collected on the 20th day of this month and shipped that same evening to my address.

Similarly we want samples collected on three or four other dates, of which you will receive due notice. Upon one of these dates, in addition to lifting the samples, we want you to supervise the lifting of all the beets in a portion of one row, see them topped, counted and weighed. At the conclusion of these trips we will pay you at the rate of \$2 a day.

Cost of bags, labels, express, etc., will be paid by us.

We presume that you will be good enough to undertake this work.

Directions.

1. Purchase cheapest grain bags in number corresponding to the number of samples that you have to collect.

2. Commence early in the morning, rain or shine, in order that you may collect all samples assigned you in one day. Box up the same and express them by the G. T. R. or C. P. R. to Guelph.

3. Upon reaching the patch of beets, look for a row marked by one stick. (There is also one row containing two sticks placed 60 feet or more apart; this row is not to be touched at present.) Begin near the stick; pull ten beets just as they come in the row, taking care not to break off tops; put them in a bag (tops and all), drop in the right label, tie the bag, place it in your wagon and drive on to repeat the same at the next and the next till all your samples are collected. You will need to carry a spade in order to lift beets without breaking off tops. Be sure that the right label, enclosed in an envelope upon which is written the number corresponding to the label number, is dropped in the bag.

4. Pack the bags of beets in a strong box, using straw or other material if necessary to fill the box in order that the beets are not jolted and bruised.

5. Drive that same evening to the nearest G. T. R. or C. P. R. station and express your box of beets to A. E. Shuttleworth, O. A. C., Guelph.

Form of Label.

Number—1 A.

Township—Malahide.

Tops and clean beets—10 lbs. 14 ozs.

Clean beets—7 lbs. 12 ozs.

Green tops—3 lbs. 2 ozs.

Tared Beets—7 lbs. 1 oz.

Number—1 A.

No. of Beets—10.

Date of pulling—26th September.

Brix 18.6 at 18 C.

Sugar in Juice—16.1.

Sugar in Beet—

Previous to the date for collecting samples, labels, numbered and dated, were mailed to the Assistant Inspectors who enclosed them with their respective samples of beets in bags. Upon the receipt of the bags at the College the beets and labels were taken out together; adhering earth brushed off, weighed (tops and all); topped and weighed again to get the weight of clean beets. By difference the weight of green tops are determined. In the earlier stages of growth the tops are heavier than the bottoms, but the bottoms outweigh the tops about the time the beets begin to mature. Therefore, the per cent. that the weight of the bottoms forms of the weight of the bottoms and tops together is of value as an indication of the degree of maturity reached at any date in the early stages of ripening.

Figure 5 shows a sample of beets brushed and ready to weigh; figure 6 shows the same sample (after tops have been removed) weighed as clean beets; and figure 7 shows the same sample of clean beets with the crowns and rootlets removed, weighed as tared beets. The above sample was lifted on October 4th, from the plot of Mr. G. A. Summers, of the Township of Malahide, Elgin Co. The weight of clean beets was 82.6 per cent. of the combined weight of the tops and clean beets, indicating advanced maturity. The clean beets averaged 1 lb. 5.8 oz., and the tared beets 1 lb. 3.5 oz. They contained 15.4 per cent. of sugar in juice, and a co-efficient of purity of 87.1. The Michigan factories this year paid for beets of such high quality between \$5 and \$5.50 per ton.

Upon September 20th, October 4th and 18th, November 1st and 15th, samples from all the patches at Aylmer and Welland were collected by the ten inspectors, and forwarded to Guelph as directed. The four local inspectors at Newmarket were notified to collect and forward samples from there to Guelph on September 25th, October 9th and 23rd, and November 6th. On the day of the arrival of the beets at the College they were first brushed, weighed, topped, &c., as in Fig. 7, and then analyzed.

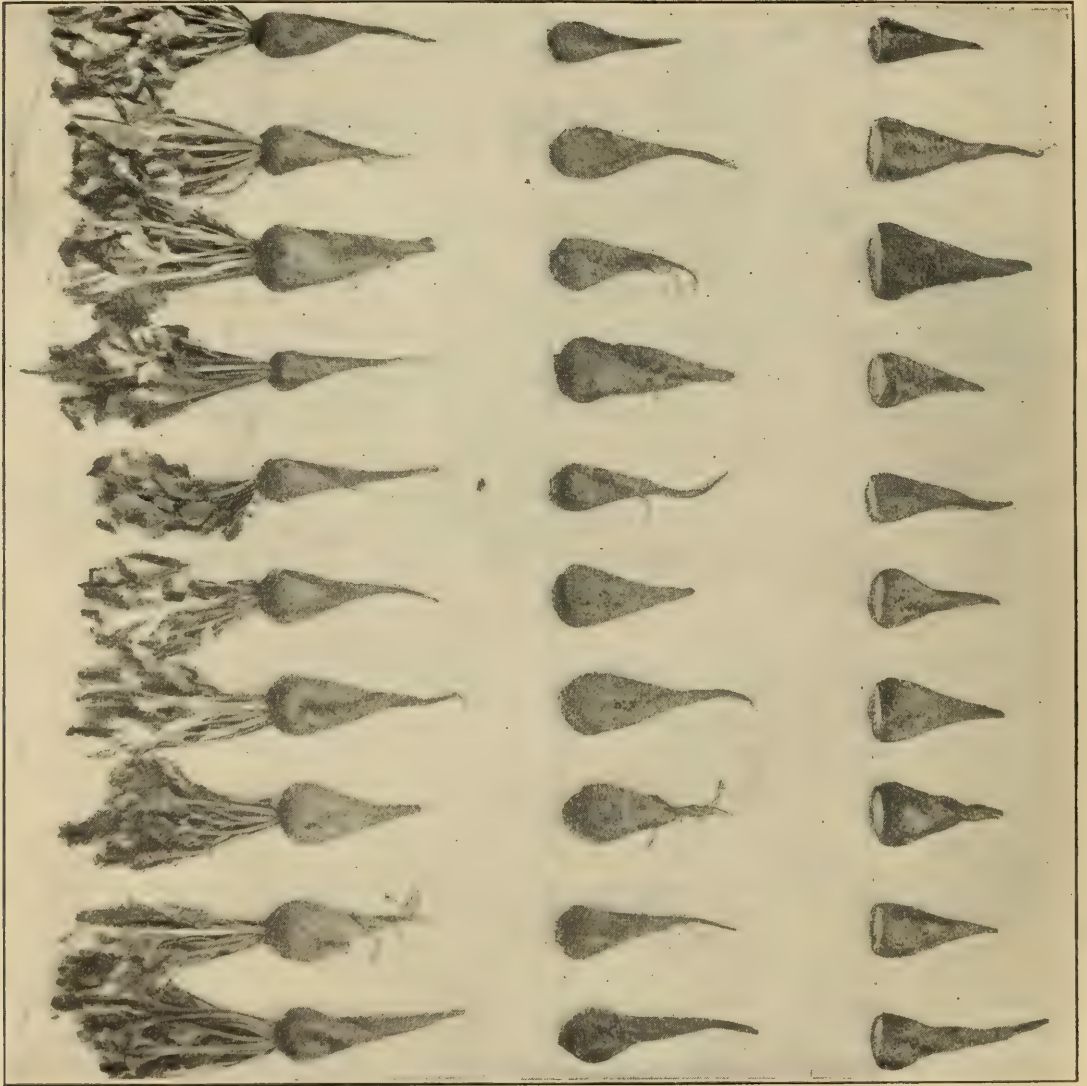


Fig. 5.

Fig. 6.

Fig. 7.

PER CENT. OF SUGAR AND CO-EFFICIENT OF PURITY IN BEET JUICE.

Every beet of a tared sample (See Fig. 7) was cut as equally as possible into two or four parts, and one of the half or quarter sections of every beet was taken to make up the sample for analysis. This sample was run through the hand-grating machine (A Fig. 8), which reduces the sample to a pulp resembling grated horse-radish. The whole of this pulp, carefully folded in a strong cotton cloth, was placed in the lever press (B. Fig. 8), and squeezed, separating the entire amount of the juice which was collected in a tin quart measure (1 Fig. 9), and allowed to stand

about twenty minutes to settle. Enough juice was then poured from this measure into a tin cylinder (2 Fig. 9) to fill it. The foam collecting on the top of the juice in the cylinder being removed, a Brix hydrometer was then lowered into and allowed to float several minutes in the juice.

One hundred pounds of sugar beets contain on an average 95 pounds of juice, and 100 pounds of average beet juice contain about 15 pounds of solids, which solids may be composed of say 12 pounds of sugar and 3 pounds of matter not sugar. This matter not sugar is largely mineral, which is a great hindrance and causes serious loss of sugar during the manufacture. Every pound of this matter not sugar keeps, practically, one pound of sugar from crystallizing. Crowns of sugar beets, leaf stems, large beets, beets grown on soils rich in vegetable matter, fertilized with

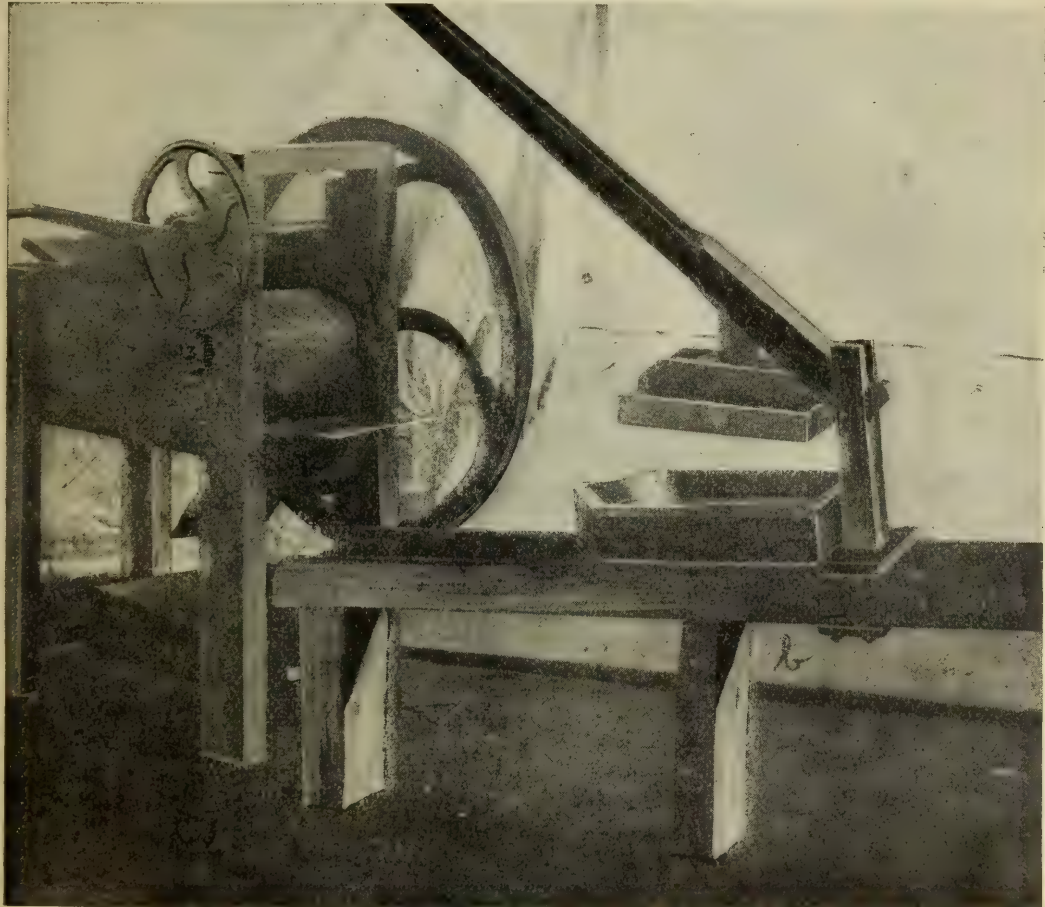


FIG. 8. HAND GRATING MACHINE.

manure or reclaimed by drainage from swamps, and immature beets, contain a large amount of this matter. Consequently, such beets and portions of beets yield juice that is not only unsatisfactory but very unprofitable to a sugar manufacturer.

When the Brix hydrometer lowered into the juice contained in the cylinder came to rest, and the temperature became constant, the graduation was read, which reading is called "Brix" and represents the total solids in the juice.

A normal weight (26.048 grams) of this juice was then accurately weighed and carefully washed into a 100 c. c. flask (3 Fig. 9). It was then clarified with lead acetate, and the flask containing it made up with water to the 100 c. c. mark. The contents of this flask being thoroughly shaken, were filtered; and the clear filtrate, which contained the sugar) collected in a clean dry breaker (4 fig. 9) was intro-

duced into the continuous polarization tube of the polariscope (fig. 10), when a reading was made, which reading represented the per cent. of sugar in the beet juice.

By dividing the Brix number, which represents the total solids in the beet

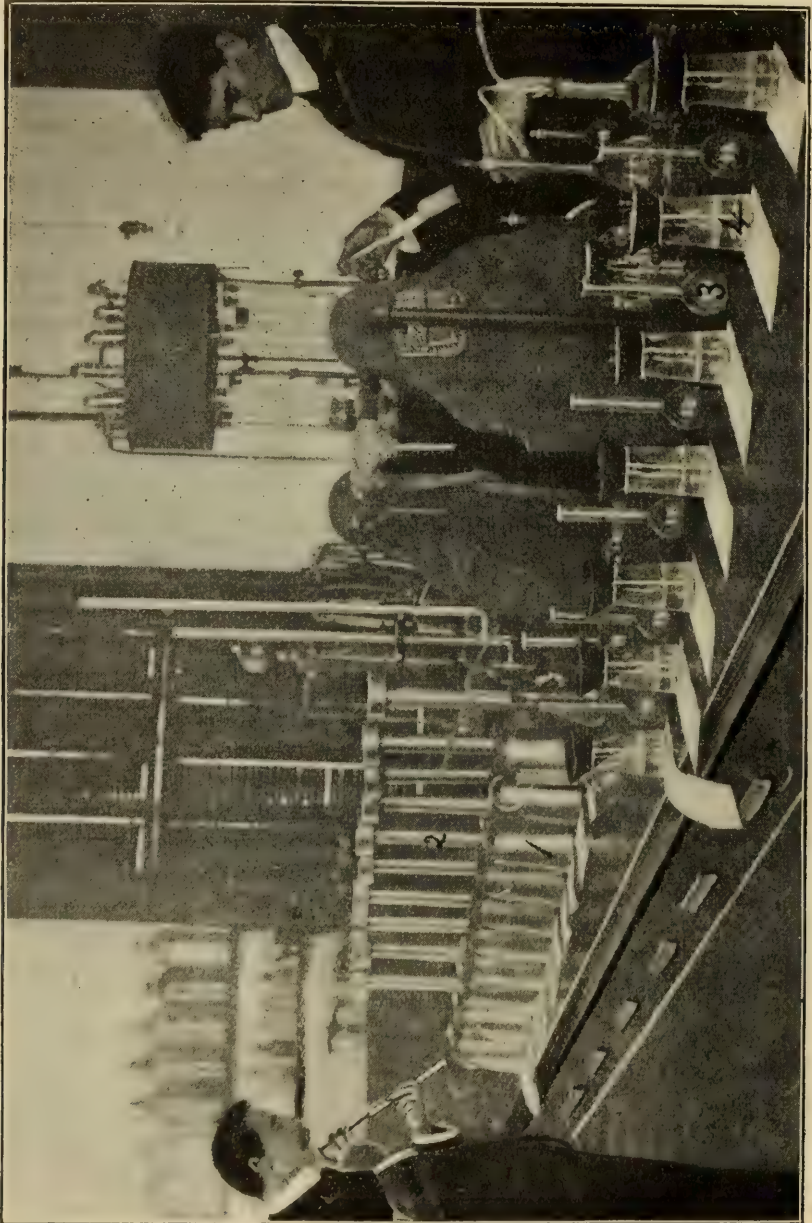


FIG. 9.

juice, into the polariscope reading which represents the per cent. of sugar in the beet juice, and multiplying the quotient by 100, a number called "Co-efficient of Purity," or simply "Purity," is obtained.

Example—

$\begin{array}{r} (1.) \text{ \% sugar in juice, } 14.5 \\ \hline \text{Brix or total solids in juice, } 16.1 \end{array}$	}	x 100 = Purity, 90.1.
$\begin{array}{r} (2.) \text{ \% sugar in juice, } 8.9 \\ \hline \text{Brix or total solids in juice, } 11.7 \end{array}$	}	x 100 = Purity, 76.1.

The beets of Example 1, cultivated on the flat in rows 21 inches apart, averaged a net weight of 1 lb. 15.4, oz., and yielded a net weight of 22 tons, 1,166 lbs. per acre ; while the beets of Example 2, cultivated in raised drills 30 inches apart, averaged a net weight of 1 lb., 9.6 oz., and yielded a net weight of 22 tons, 500 lbs. per acre.

Upon the assumption that each pound of matter not sugar in the solids of beet juice keeps at least one pound of sugar from crystallizing, 88.9% of the sugar in the

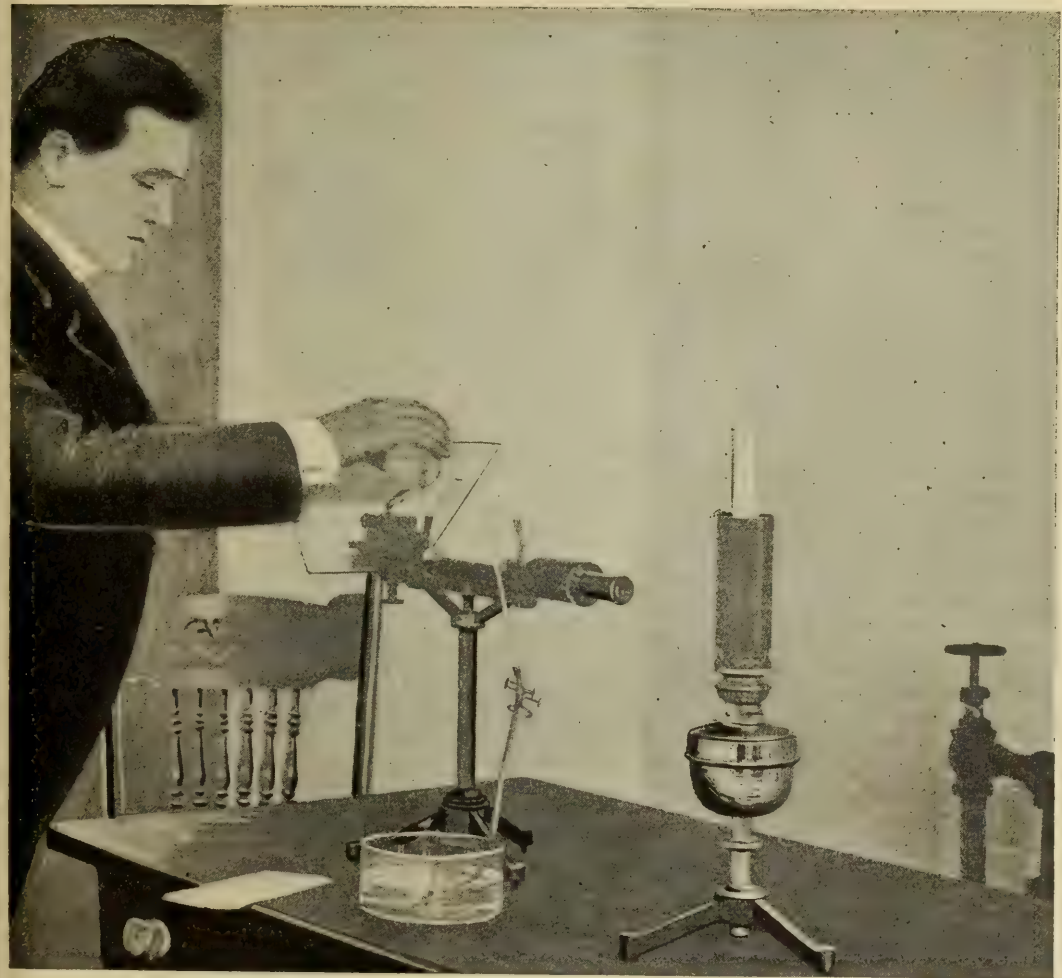


FIG. 10.

beets of Example 1, and only 68.5 of the sugar in the beets of Example 2, would crystallize. This enormous loss of sugar which in the latter case would occur will not happen when farmers fully realize and practice proper methods of cultivation. The beets of Example 2 were grown on excellent sugar beet soil, but cultivated as commonly practiced for feeding and exhibition purposes ; while those of Example 1 were cultivated strictly according to the printed directions guiding the farmers in this experiment.

AYLMER EXPERIMENT.

No.	Name.	Post Office.	Particulars noted at time of third inspection.
1	Haggan, J. C...	Aylmer	A carefully cultivated patch ; doing well.
2	Doolittle, W. ..	Luton.....	Only a fair patch. Grasshoppers damaged the leaves.
3	Hale, J. M	Luton	An even, full patch ; well looked after.
4	Jackson, F.....	Aylmer	Very rank growth and looking well.
5	Harper, S. S. ..	Aylmer	Has been a little neglected owing to pressure of other work.
6	Dancey Bros. ..	Aylmer	Neglected cultivation owing to pressure of other work.
7	Mitchell, A	Aylmer	Neglected cultivation at time required owing to other work.
8	Harper, S. B....	Aylmer	A fairly good crop.
9	Summers, G. A. Aylmer	.....	One of the fine looking crops ; clean, full and even.
10	Summers, B....	Aylmer	Beets contain a dark rusty foliage.
11	Sisler, J.....	Aylmer	The patch is simply magnificent in all respects.
12	Bates, B. E....	Aylmer	A magnificent crop in all respects.
13	Caron, J. A	Aylmer	Many blanks, and beets not growing well.
14	Harp, W	Aylmer	Clean, but being in rows 24 inches apart the patches may produce immature beets.
15	Timpany, C....	Aylmer	A good patch, properly cultivated.
16	Learn, C. O	Aylmer	A choice patch ; full and clean.
17	Fansher, W	Aylmer	A choice patch.
18	Rodgers, S.....	Aylmer	Clean, pretty and even.
19	Pound, A	Sparta	Entirely fine in every respect.
20	Disher, H	Sparta	A patch of coarse, large beets, not very carefully spaced.
21	Ashton, J. J.	Port Bruce..	The growth is remarkable, and cultivation good.
22	Jones, R. R....	Copenhagen	Clean, fairly even, and rank.
23	Wilson, J. A ...	Copenhagen	Unfortunately planted in an orchard of large trees.
24	Gillott, J. M ...	Copenhagen	Fine crop in good condition.
25	Vanslyke, A. E..	Copenhagen	Seed failed to germinate, and plot not reseeded.
26	Tyrrell, A	Dunboyne..	Full stand of plants, neither thinned nor cultivated.
27	Pound, J. K....	Dunboyne..	A real pretty crop, faithfully cultivated.
28	Tufford, N. F...	Dunboyne..	A good crop, clean and even.
29	Pressy, J. H....	Mt. Salem..	Growthy patch of beets containing blanks.
30	Gerharts, C	Mt. Salem..	Clean and even ; carefully cultivated.
31	Heffer, F	Calton	Rank growth; many blanks; soil contains undecayed solids.
32	Timpany, J. H..	Calton	Rows 30 inches apart ; growth rank.
33	Van Patter, J..	Luton.....	Equal to the best patches I have ever seen in Germany. Five beets taken as they came in an average row weighed 7½ lbs., the largest of which weighed 2½ lbs and the smallest 1 lb.
34	Miller, H	Aylmer	Not a very full crop.
35	Dunn, F.	Luton.....	A very pretty patch ; clean, regular and full.
36	Crosby, J. S. ..	Dunboyne..	This patch is entirely satisfactory ; full, even and heavy.
37	Johnston, T	New Salem	Entirely uncultivated.
38	Dance, J. C	Kingsmill ..	This patch is entirely fine, full, clean and even.
39	Dawes, S	Springfield .	Beet patch grand, but rows unfortunately 24 inches apart.
40	McLachlin, D..	Springfield .	Even, clean and properly cultivated ; fairly full crop.
41	Woodworth, W.	Glen Colin..	Magnificent in every respect.
42	Disbrowe, G.	Glen Colin..	Not a full patch, but doing nicely.
43	Timpany, L. J..	Aylmer	A good crop ; very carefully spaced in rows.
44	Skinner, J	Aylmer	Among the cleanest and finest patches.
45	Clarke, C. M...	Aylmer	Patch neglected.
46	Thompson, W..	Aylmer	A beautiful patch
47	Summers, J. R..	Aylmer	A very heavy patch of rankly growing beets.
48	Schneider, J....	Aylmer	First seeding failed owing to grubs eating off the plants but the second succeeded fairly well.
49	Marchant, T...	Aylmer	Cultivation a little neglected owing to lack of health.
50	Caverly, E.....	Aylmer	First seeding failed owing to grubs ; reseeded, securing a magnificent patch.
51	Wallace, —...	Aylmer	Sown late, but growing nicely.
52	Teeple, W. H..	Aylmer	Fine crop.

AYLMER EXPERIMENT.

Average weight of Beets, per cent. Sugar, and Purity in Juice of Beets.

Lifted on Five Different Dates.

Experim'ters No.	September 20th.			October 4th.			October 18th.			November 1st.			November 15th.			Average for season.	
	Beet oz.	Sugar.	Purity.	Beet oz.	Sugar.	Purity.	Beet oz.	Sugar.	Purity.	Beet oz.	Sugar.	Purity.	Beet oz.	Sugar.	Purity.	Sugar.	Purity.
1	12.4	16.1	86.5	13.0	15.0	86.2	13.6	15.0	88.2	15.0	14.4	86.2	9.8	15.9	91.9	15.3	87.8
2	14.8	16.4	83.7	26.4	13.0	83.9	18.2	13.0	88.4	.....	*	.....	17.8	11.7	87.3	13.5	85.8
3	25.8	15.1	82.1	20.0	13.3	76.9	17.1	15.2	88.4	17.7	13.9	85.3	19.6	13.2	87.4	14.1	84.0
4	15.1	12.9	82.2	28.1	13.1	81.9	20.8	14.4	84.7	20.3	14.2	86.6	24.4	13.4	86.4	13.6	84.3
5	22.2	13.8	84.2	26.8	13.5	81.6	26.8	14.9	88.1	21.8	15.2	87.8	34.0	14.2	87.3	14.5	85.8
7	10.4	15.6	87.6	8.5	15.9	88.3	14.2	14.1	86.5	8.7	14.7	91.9	16.5	15.2	87.8	15.1	88.4
8	19.5	15.1	84.8	15.2	12.9	84.3	12.8	14.8	87.6	15.8	13.9	85.8	18.6	13.5	85.9	14.0	85.7
9	22.9	15.0	82.4	21.8	15.4	87.1	20.8	16.3	89.1	24.0	14.8	89.7	35.8	14.5	90.1	15.2	87.7
10	16.0	13.2	85.2	12.6	13.4	86.5	9.8	12.7	90.1	12.1	12.6	88.7	22.2	11.4	84.4	12.7	87.0
11	22.7	13.2	82.5	24.8	14.7	86.5	31.7	14.8	88.6	30.3	14.9	88.2	31.3	15.2	92.1	14.5	87.6
12	15.6	15.5	85.6	15.6	13.2	85.2	18.8	14.1	83.9	13.4	13.7	85.1	14.8	14.3	91.1	14.2	86.2
13	5.2	13.9	78.1	7.2	9.1	72.8	5.8	11.5	85.8	7.8	11.5	77.7	7.0	11.4	78.6	11.5	78.6
14	12.8	15.0	85.7	13.1	15.1	88.8	12.1	14.6	87.4	11.7	14.2	87.1	15.6	12.1	85.8	14.2	87.1
15	8.4	14.5	83.3	8.9	15.2	88.9	11.3	14.7	91.3	15.5	13.5	85.4	27.1	12.1	82.3	14.0	86.2
16	10.2	16.0	86.5	15.7	13.3	83.1	20.0	14.4	85.7	18.9	15.0	92.6	25.3	14.5	86.8	14.6	86.9
17	21.0	14.9	82.3	28.2	13.9	81.3	25.2	15.0	82.9	30.5	14.4	88.9	26.3	14.9	89.8	14.6	85.0
18	9.3	14.9	81.9	13.4	14.7	85.0	12.9	13.4	86.5	10.8	12.5	82.8	12.4	12.8	85.9	13.7	84.4
19	18.2	16.4	85.4	17.5	14.2	82.1	19.3	15.5	87.6	17.5	15.2	87.3	16.4	14.4	89.4	15.1	86.3
20	43.8	13.1	79.4	28.8	14.7	83.5	36.2	14.3	85.6	44.8	14.5	85.5	36.4	17.1	91.4	14.7	85.1
21	21.6	13.9	82.7	17.1	13.4	83.2	20.7	13.4	81.7	25.7	13.2	84.1	29.9	13.4	83.2	13.4	83.0
22	15.2	15.0	88.2	16.8	14.2	85.6	13.8	14.7	90.2	12.4	15.6	90.2	19.0	12.7	82.5	14.4	87.3
23	11.0	14.0	87.5	16.3	12.4	80.0	17.0	11.6	82.9	15.1	14.2	84.5	21.4	12.8	83.6	13.0	83.7
24	20.1	14.0	85.4	34.8	12.8	84.2	23.8	14.4	86.8	.....	*	.....	28.4	13.7	88.4	13.7	86.2
27	17.9	13.9	82.7	21.6	11.0	78.6	25.2	11.9	80.9	15.4	12.8	83.7	22.0	13.3	84.7	12.6	82.1
28	7.2	17.1	89.5	9.1	15.5	88.1	9.8	15.7	91.8	8.4	15.2	91.6	14.2	14.5	86.8	15.6	89.5
29	21.2	15.3	88.9	14.0	15.8	85.9	18.2	15.2	87.9	23.2	15.1	88.3	19.8	14.3	86.7	15.1	87.5
30	9.6	15.8	90.8	16.2	13.5	86.5	12.6	15.2	88.4	16.7	15.0	92.0	14.9	14.4	89.4	14.8	89.4
31	9.3	16.5	88.7	10.9	15.2	88.4	12.4	15.8	92.9	13.6	15.3	90.5	.....	*	.....	15.7	90.1
32	41.0	7.7	64.2	27.0	7.6	63.9	14.9	9.2	57.1	23.0	8.8	69.3	35.2	12.2	77.7	9.0	66.4
33	15.2	18.0	87.8	19.8	16.1	87.5	19.3	15.2	84.4	23.8	15.7	92.4	24.7	14.0	86.9	15.8	87.8
34	7.6	15.0	86.2	12.0	13.9	83.2	24.9	14.1	83.4	18.9	14.8	86.5	12.8	14.0	87.5	14.8	85.5
35	13.1	16.0	88.4	12.3	15.2	86.4	20.2	14.9	88.1	20.9	15.0	89.3	15.8	14.8	87.1	15.2	87.8
36	14.0	15.9	87.4	15.3	15.1	89.9	11.5	15.3	90.0	19.0	13.3	76.4	19.3	15.7	90.2	15.1	86.8
38	15.0	16.5	85.9	12.3	16.1	95.6	16.9	16.2	87.1	12.4	16.3	88.6	20.8	15.4	87.0	16.1	86.8
39	17.9	15.5	87.1	19.8	14.9	89.2	18.0	16.0	85.1	20.8	15.0	88.2	13.0	15.2	85.8	15.3	87.1
40	17.8	14.0	80.5	22.8	13.1	81.3	24.7	14.1	87.6	19.2	13.8	83.6	20.9	13.7	84.0	13.7	83.4
41	13.1	13.9	86.3	13.9	13.5	79.6	14.4	15.2	89.9	9.5	14.0	92.7	10.2	13.5	87.1	14.0	87.1
42	9.6	16.0	87.9	10.7	15.3	85.5	13.1	15.2	83.9	10.3	15.0	86.7	10.9	15.3	90.5	15.4	86.9
43	17.0	16.0	82.1	18.7	13.5	81.1	19.1	16.2	83.9	22.6	15.2	84.4	16.2	14.5	81.9	15.0	82.7
44	17.7	14.4	84.7	19.5	15.2	85.4	15.6	15.3	85.5	13.6	15.2	89.4	16.4	14.5	83.8	14.9	85.8
46	11.0	16.6	84.7	16.0	15.2	81.3	18.4	17.1	87.7	18.2	15.7	86.3	16.8	14.2	81.6	15.8	84.3
47	28.8	13.7	81.1	28.0	12.1	78.6	25.3	13.9	83.7	31.0	13.6	82.4	43.6	11.5	77.2	13.0	80.6
48	.....	*	.....	10.9	15.2	84.9	13.8	15.0	91.5	15.0	14.2	88.8	16.8	14.2	91.6	14.6	89.2
49	9.5	15.9	83.7	10.8	14.0	84.3	12.3	13.3	84.2	15.0	14.6	88.5	13.0	14.2	87.6	14.4	85.7
50	13.7	13.0	80.7	16.8	13.2	83.0	23.4	14.9	87.6	24.6	13.5	87.7	31.4	11.7	82.4	13.1	84.3
51	14.6	12.5	78.1	13.4	12.5	75.8	17.2	13.2	83.0	28.0	12.2	80.3	19.1	14.2	88.2	12.9	81.0
52	16.2	14.9	84.7	17.3	15.7	84.4	21.3	13.8	77.1	23.3	14.2	82.1	20.0	14.9	81.8	14.7	82.0

* No samples received.

WELLAND EXPERIMENT.

No.	Name.	Post Office.	Particulars noted at time of third inspection.
1	McAlpine, A....	Welland ...	Patch admired by farmers ; is carefully cultivated.
2	Kottmeier, J....	Welland ...	Sub-soil hard, the patch suffered during the dry weather.
3	Damude, J.	Fonthill....	A fairly heavy crop, looking well.
4	Platts, Wm.	Fonthill....	Mr. P., being overworked with the packing of his small fruits, neglected surface cultivation. The patch, though more than fair, is not up to my expectations.
5	Taylor, C.	Fonthill ...	A choice crop ; well looked after.
6	Holditch, H. H.	Ridgeville..	Not planted according to directions ; many blanks.
7	Van Every, S....	Ridgeville..	A beautiful crop ; clean and even.
8	Hill, H. E.	Ridgeville..	A pretty crop ; doing well.
9	Hill, J. G.	Ridgeville..	Crop has considerably surpassed expectations of May 31st.
10	Stirtzinger, F....	Fenwick ...	Practically perfect, except a few blanks caused by grubs.
11	Sloat, J. C.	Fenwick ...	The dry hot weather has checked growth a little. This was one of the finest patches early in the summer.
12	Stirtzinger, H....	Fenwick ...	Too many blanks. Patch otherwise looking well.
13	Fry, W. H.	Fenwick ...	Seed did not germinate, the ground being dry and open.
14	Ker, E.	Fenwick ...	Dry weather was hard. The soil by drifting has covered many plants. Other portions doing well.
15	Reece, J. W.	Fenwick ...	Did not follow directions, and failed to get a catch.
16	Beamer, A.	Fenwick ...	Owing to pressure of work, decided to plant for feeding.
17	Stirtzinger, P....	Fenwick ...	Well cultivated and doing nicely.
18	Atkins, E. S.	Fenwick ...	Seed planted on dry lumpy ground failed to germinate.
19	Horton, W. L.	N. Pelham..	A heavy clay soil which crusted, killed the young plants.
20	Brown Bros ...	Br. Nurseries	By a misunderstanding planting was delayed until too late.
21	King, W. H.	Fonthill ...	Failed to germinate owing to the dry condition of seed bed.
22	Haist, D.	Pelham C..	Germination failed for the reason that the ground was spring plowed leaving it too open and dry.
23	Ward, J.	Ridgeville..	Cultivated according to directions. His crop is beautiful.
24	Chantler, E.	Chantler....	Cultivation right, and crop entirely satisfactory.
25	Henderson, C....	Marshville..	Germination failed owing to the open dry seed bed.
26	Misener, F. E.	Marshville..	The young plants make slow growth in the hard dry soil.
27	Stevenett, S.	Winger.	Cultivation somewhat neglected.
28	Tunnacliffe, J..	Marshville..	Open dry soil, seed did not germinate. A second seeding after making soil firmer, and therefore more moist, germinated, and beets are growing well.
29	Sider, C.	Perry Sta...	Many blanks ; rows not evenly spaced, nor straight.
30	Sider, J.	Winger	A very heavy growthy looking crop, but the rows are not evenly spaced and contain blanks.
31	McNeil, W. T..	Fonthill....	Carefully planted, but the beets are rather small owing to the hardness and dryness of the soil.
32	Berriman, T....	Stamford ...	Entirely satisfactory.
33	Garner, A.	Southend...	Soil not properly cultivated before planting.
34	Huggins, B.	Thorold	Cultivation neglected owing to lack of assistance.
35	Cole, D.	Southend...	Suffering from drouth, carefully planted and cultivated.
36	Gallinger, J. B.	Southend...	Seed germinated, but plants were killed by a top dressing of poultry manure.
37	Pettit, A. C.	Southend...	Many blanks by deep planting. Cultivation satisfactory.
38	Mitchell, H.	Southend..	Planted on mangel drills of lumpy soil ; did not germinate.
39	Elliff, J.	St. John's ..	A fine crop, but too far off to be included in experiment.
40	McAlpine, W....	Welland....	On new soil, and seed germinated poorly.
41	Garner, J.	Fenwick	Cultivated as mangels on raised drills 30 inches apart.
42	Depew, J.	Southend...	Owing to pressure of work did not plant.
43	Bouk, J.	Southend...	Many blanks ; rows 24 inches apart.
44	Hutt, F. A.	Southend...	Carefully planted and cultivated properly.
45	Hemmings, J....	Welland	A beautiful crop ; carefully cultivated.
46	West, W. A. N.	St. Cath'...	Too far away to be included in the experiment.
47	Swayze, E.	Fonthill....	Too far away to be included in the experiment.
48	Damude, A.	Fonthill....	Patch neglected.
49	Overholt, D. D..	Fonthill....	A fine crop in good condition.
50	Brady, M.	Thorold	Too far away to be included in the experiment.
51	Hyatt, A.	Pelham C..	Did not plant seed.
52	.....	.....	Fairly even crop of beets.

WELLAND EXPERIMENT.

Average weight of Beet per cwt., Sugar and Purity in Juice of Beets.
Lifted on Five Different Dates.

Experimenter's No.	September 20th.			October 4th.			October 18th.			Nov'r 1st.			Nov'r 15th.			Average for season.	
	Beet oz.	Sugar.	Purity	Beet oz.	Sugar.	Purity.	Beet oz.	Sugar.	Purity.	Beet oz.	Sugar.	Purity.	Beet oz.	Sugar.	Purity.	Sugar.	Purity.
1	14.6	15.5	84.7	14.9	14.7	86.5	17.0	14.8	87.1	17.0	14.8	87.1	15.0	15.2	84.9	15.0	86.1
2	13.3	15.1	81.6	12.8	12.1	77.6	15.5	14.0	88.1	10.7	14.5	86.3	17.6	13.7	83.0	13.9	83.3
3	14.3	16.5	85.1	12.7	15.4	86.0	18.7	14.6	84.4	15.8	14.3	89.4	...	*		15.2	86.2
4	18.1	15.1	82.1	16.6	14.5	87.4	21.3	14.6	86.9	21.4	13.4	86.5		*		14.4	85.7
5	30.2	12.3	80.9	26.4	11.4	78.6	21.3	12.3	80.3	20.8	13.0	80.7	20.2	12.0	84.5	12.2	81.0
6	28.3	13.4	85.9	28.0	13.0	82.6	19.2	15.3	89.5	17.5	12.7	80.4	16.0	14.4	87.3	13.8	85.1
7	18.4	16.5	87.3	17.2	15.5	89.1	13.8	15.0	90.9	13.2	14.7	88.0	17.6	15.0	88.8	15.3	88.8
8	11.8	17.3	84.6	12.4	14.8	85.1	11.1	15.2	85.4	17.6	14.4	82.8	14.7	15.2	86.8	15.4	84.9
9	9.3	16.7	88.4	5.6	15.1	87.3	13.6	16.9	90.9	14.0	15.5	84.7	9.6	18.0	90.5	16.4	88.4
10	8.4	18.0	87.0	7.7	15.1	86.7	5.8	15.8	94.0	10.8	16.0	89.4	8.2	15.4	85.6	16.1	88.5
11	9.1	16.2	86.2	15.8	14.7	89.1	9.2	15.5	88.6	12.8	13.9	86.3	13.2	15.1	89.4	15.1	87.9
12	12.6	16.8	86.6	19.9	14.2	87.1	18.2	15.6	89.7	8.4	16.2	90.5	12.7	16.0	88.4	15.8	88.5
14	11.8	15.4	83.7	12.1	13.1	85.1	23.9	13.5	85.5	18.4	13.6	87.1	12.7	13.9	84.7	13.9	85.2
16	20.7	14.0	83.3	21.1	13.6	84.7	17.8	14.4	88.3	18.0	12.2	83.5	28.9	14.7	85.9	13.8	85.1
17	11.4	15.5	81.6	10.6	14.4	87.3	8.9	16.3	89.5	15.4	15.8	90.3	14.2	15.1	92.1	15.4	88.2
23	12.8	15.2	80.8	9.4	12.5	82.8	10.0	13.6	86.1	10.8	13.9	87.9	14.2	12.9	83.2	13.6	84.2
24	13.6	16.2	84.8	13.2	13.3	80.1	14.0	15.1	85.3	10.4	16.5	89.7	13.7	14.4	86.2	15.1	85.2
26	10.2	14.9	80.5	15.5	14.1	83.9	14.0	16.0	87.4	21.0	14.9	88.7	18.2	16.1	86.1	15.2	85.3
27	11.0	15.0	85.2	13.6	15.3	86.9	18.5	15.2	86.4	16.3	14.7	86.9	15.4	15.4	85.6	15.1	86.4
28	11.2	12.3	79.9	15.9	11.3	76.9	19.4	13.8	82.1	21.7	14.1	85.4	16.0	14.4	85.2	13.2	81.9
29	23.1	14.2	84.0	17.8	13.1	79.4	13.0	15.6	89.6	12.3	16.2	90.5	10.1	16.9	90.4	15.2	86.8
30	50.1	10.2	75.6	40.0	9.4	70.1	44.8	9.3	76.2	28.2	9.7	72.9	45.4	10.0	70.4	9.7	73.0
31	6.8	20.0	86.2	10.0	15.8	84.0	16.0	15.6	83.9	9.2	16.3	90.1	13.7	16.1	87.0	16.8	86.2
32	8.7	16.6	87.4	10.2	16.3	87.6	6.4	15.2	89.9	13.8	15.3	88.4	11.5	15.8	89.3	15.8	88.5
33	18.9	13.6	72.3	4.0	14.8	83.2	18.5	14.2	81.2	10.8	15.2	80.4	14.6	14.7	83.5	14.5	80.1
34	13.5	14.7	79.9	19.8	13.9	82.7	55.8	13.1	84.5	18.2	13.1	75.7	16.5	14.9	87.1	13.9	81.9
35	10.1	18.4	87.6	7.2	16.8	87.0	10.3	16.2	88.0	13.3	15.0	83.8	11.2	17.3	90.1	16.7	87.3
37	10.6	16.2	86.6	8.0	14.2	85.5	10.3	15.2	89.9	8.0	15.2	92.1	8.2	15.0	89.8	15.2	88.8
39	8.3	17.1	86.8	...	*	...	...	*	...	...	*	...	...	*	...	*	...
40	25.1	15.4	80.6	16.9	15.5	82.4	27.1	14.4	87.8	21.2	15.1	86.8	18.2	13.4	82.7	14.8	84.1
41	29.2	8.2	70.7	30.4	8.7	73.1	25.7	8.5	73.9	47.5	13.3	83.6	32.7	8.9	76.1	9.5	75.5
43	21.6	13.6	77.3	19.2	12.1	74.7	20.3	13.3	88.7	19.2	12.5	80.1	30.4	9.9	71.2	12.3	78.4
44	12.4	13.4	79.8	19.6	12.7	77.4	20.0	11.1	80.4	18.3	13.1	81.4	21.3	13.8	82.6	12.8	80.3
45	12.0	16.5	82.5	17.2	13.6	82.9	18.3	14.2	89.3	15.4	14.2	84.5	22.1	13.0	78.8	14.3	83.6
48	8.9	15.3	81.4	3.0	14.5	84.8	83.3	11.7	84.8	10.6	14.8	87.0	...	*	...	14.1	84.5
49	13.8	12.6	80.8	14.3	12.5	81.7	15.0	14.4	85.7	12.8	15.1	88.8	...	*	...	13.6	84.2
52	15.1	12.3	72.8	19.5	10.8	71.5	22.3	12.7	75.6	22.4	12.7	77.4	18.6	13.2	79.5	12.3	75.4

* No samples received.

NEWMARKET EXPERIMENT.

No.	Name.	Post Office.	Particulars noted at time of third inspection.
1	Lundy, S. E	Newmarket.....	Only a fair plot ; insufficient cultivation.
2	Morrison, C. K	Newmarket. . .	Rather poor patch.
3	Wriggett, R. J.	Newmarket.	A fine patch.
4	Pegg, E. H.	Paardeberg.....	A fine patch of strong growthy beets.
5	Pegg, W. J.	Paardeberg.....	A fine plot, but not so uniform as 4.
6	Tansley, W. T.	Paardeberg.....	Being badly neglected, is a poor patch.
7	McDonald, D. C.	Ravenshoe.....	An extra fine patch of beets.
8	Cowieson, J. T..	Ravenshoe... ..	Patch a little uneven, but very good beets.
9	Weddel, R. H..	Ravenshoe.....	Second seeding sown very late, but beets doing well.
10	Cowieson, W. R.	Queensville.....	A good patch.
11	Cowieson, J. . .	Queensville.....	Did not plant seed.
12	Cowieson, W. N.	Queensville.	Cultivation neglected.
13	Curtis, C. H.	Newmarket	Badly cut by hail storm early in the season. Patch properly cultivated.
14	Wright, J.	Holland Landing .	Only a fair patch.
15	Brammer, A. E.	Holland Landing .	A good patch.
16	Lundy, C. E . . .	Holland Landing .	A fine patch with few blanks ; very clean ; might have been better cultivated.
17	Grose, D.	Holland Landing .	Not well cultivated.
18	Roode, G. W. . .	Holland Landing .	Patch in garden ; growth rank.
19	Murphy, Wm . .	Holland Landing .	Patch in garden ; carefully cultivated.
20	McClure, W . . .	Newmarket	Many blanks.
21	Midlard, T.	Holland Landing .	Did not sow.
22	Proctor, J. H . .	Newmarket	Appearance satisfactory.
23	Lewis, T. A . . .	Newmarket	A good patch.
24	Lemon, Simeon.	Kettleby	A fair patch.
25	Dennis, R. R. . .	Aurora	A fair patch.
26	Phillips, R. W. .	Aurora	A good patch.
27	Dyke, W. A.	Newmarket	A good patch.
28	Everett, T.	Newmarket	Planted too deeply, came up only in places.
29	Doan, Charles F.	Newmarket	Only fair
30	Kavanagh, J. . .	Newmarket	Carefully cultivated.
31	Lewis, C.	Newmarket	A fair patch.
32	Starr, W. N.	Newmarket	A fairly good patch.
33	Starr, A. E.	Bogarttown	Carefully cultivated.
34	Lehman, P.	Pine Orchard	Only fair.
35	Case, C.	Pine Orchard	Cultivation somewhat neglected.
36	Spalding, T. J. .	Pine Orchard	An extra fine patch.
37	Widdifield, E. .	Newmarket	A very fair patch.
38	Belfry, R. H. . .	Holland Landing .	Growth rank.
39	Cocklin, M. . . .	Newmarket	Fairly uniform.
40	Ashley, B.	Newmarket	An exceptionally strong growing patch.
41	Roe, A. E.	Newmarket	Plowed under because they came up light.
42	Clarkson, T.	Kettleby	An extra good patch ; well cultivated.
43	Doan, W. A.	Newmarket	Large coarse beets.
44	Stevens, J. W. .	Newmarket	A poor patch ; not well cultivated.
45	Starr, M.	Pine Orchard	A good patch.

NEWMARKET EXPERIMENT.

Average weight of beet, per cent. sugar, and purity of juice in beets.
Lifted on five different dates.

Experi- menter's No.	September 25th.			October 9th.			October 23rd.			November 6th.			Average for season.	
	Beet ozs.	Sugar.	Purity.	Beet ozs.	Sugar.	Purity.	Beet ozs.	Sugar.	Purity.	Beet ozs.	Sugar.	Purity.	Sugar.	Purity.
1	17.0	15.8	81.0	15.2	14.7	85.4	16.0	12.6	81.3	16.0	13.6	81.4	14.2	82.3
2	14.8	16.6	83.8	28.6	14.0	80.9	*			*			15.3	82.4
3	11.1	15.4	82.8	15.6	13.8	83.6	24.0	13.5	84.4	19.5	15.0	82.9	14.4	83.4
4	13.6	17.0	83.3	12.0	16.4	85.8	15.2	14.8	85.6	16.4	14.8	81.7	15.7	84.1
5	20.7	13.9	80.8	17.7	13.0	81.1	26.6	14.6	85.9	20.9	16.1	87.0	14.4	83.7
6	16.0	15.6	83.4	15.7	14.1	81.4	20.0	13.6	83.9	23.1	14.0	85.4	14.3	84.3
7	29.8	12.5	76.2	31.2	11.8	75.6	29.1	12.1	78.1	26.5	12.5	76.2	12.2	76.5
8	17.0	15.4	84.6	16.8	14.8	85.5	15.1	15.5	88.6	15.8	15.1	85.8	15.2	86.1
9	20.9	14.1	79.7	*			*			*			14.1	79.7
10	9.4	15.2	82.6	17.2	14.3	86.1	16.7	13.7	86.7	20.0	14.7	87.5	14.5	85.7
11	19.0	15.4	85.6	18.5	16.3	89.0	18.3	15.4	86.5	18.1	16.5	88.2	15.9	87.3
12	15.4	17.0	86.3	20.6	15.9	84.5	20.2	14.7	86.5	22.9	16.0	86.9	15.9	86.0
13	11.6	15.8	84.0	11.3	17.7	90.7	13.4	15.1	87.3	13.9	16.9	90.4	16.4	88.1
14	19.8	14.4	79.6	20.7	13.8	79.9	22.2	14.0	86.4	....	....	....	14.1	81.9
15	20.5	17.5	86.6	17.8	15.6	84.3	26.4	14.7	84.9	17.0	15.2	83.5	15.7	84.8
16	17.2	12.1	75.6	14.9	12.7	77.9	11.0	13.9	83.7	8.1	14.9	83.2	13.4	80.1
17	12.8	14.5	79.7	19.7	13.7	83.5	18.4	12.5	82.2	21.8	16.1	84.3	14.2	82.4
18	14.2	9.1	64.1	18.0	10.6	70.2	15.1	10.5	68.6	12.9	12.0	76.4	10.5	69.8
19	*	....	....	13.9	11.2	69.9	18.8	13.2	85.1	15.6	15.1	85.9	13.1	80.3
20	15.2	16.9	84.1	12.8	15.8	84.9	14.4	16.2	86.2	15.8	15.5	87.6	16.1	85.7
21	13.1	17.9	82.1	10.9	17.2	84.7	11.3	15.2	82.6	15.2	15.0	83.8	16.3	83.3
22	16.7	17.2	84.3	21.1	16.0	86.0	19.8	15.9	87.3	21.1	17.5	86.6	16.6	86.0
23	16.4	15.7	83.5	19.3	14.7	82.1	20.0	14.3	84.1	26.0	15.4	84.1	15.0	83.4
24	53.0	12.5	76.2	26.1	15.2	82.1	80.3	11.7	78.0	49.8	13.2	81.5	13.1	79.4
25	8.6	19.3	85.0	10.1	17.2	89.1	11.2	16.8	87.9	20.9	15.7	87.2	17.2	87.3
26	21.2	15.9	82.8	18.0	16.3	79.1	20.1	16.6	86.9	32.3	15.4	80.6	16.0	82.3
27	12.1	16.7	86.1	16.9	16.2	87.5	12.2	15.7	87.2	18.1	16.5	87.3	16.3	87.0
28	23.4	16.2	83.9	23.4	16.5	82.7	23.3	16.3	88.1	27.2	15.4	84.6	16.1	84.8
29	13.5	16.7	87.9	9.8	16.2	90.5	9.0	15.2	80.5	14.5	15.1	85.3	15.8	86.0
30	13.6	12.0	73.2	10.7	14.4	81.3	19.2	13.6	81.3	23.6	13.2	75.4	13.3	77.8
31	10.2	16.0	85.6	10.0	12.3	75.4	8.0	13.2	80.0	8.4	15.6	85.2	14.3	81.5
32	10.0	15.8	81.9	19.7	13.2	80.4	20.8	13.2	80.9	21.7	15.1	87.3	14.3	82.6
33	13.6	16.5	83.8	14.2	15.2	87.9	15.6	14.5	84.3	17.9	15.6	86.2	15.4	85.5
34	21.9	13.1	78.9	25.1	14.0	85.9	26.6	13.7	83.0	....	*	....	13.6	82.6
35	37.9	14.5	81.0	40.8	14.2	83.0	28.4	15.2	87.4	*	....	....	14.6	83.8
36	13.7	15.1	84.4	20.9	15.2	84.9	22.9	14.1	90.4	24.1	13.9	84.2	14.6	86.0
37	14.4	14.2	73.2	16.6	15.2	83.0	16.2	12.8	76.2	18.6	14.4	79.6	14.1	78.0
38	15.3	16.7	81.9	9.1	14.2	82.0	9.8	12.5	82.2	12.6	13.9	79.4	14.3	81.4
39	13.5	16.9	91.9	12.5	15.5	86.1	8.6	15.0	88.2	12.8	16.5	87.3	16.0	88.4

* No samples received.

NOTES ON RESULTS OF EXPERIMENTS.

All have not succeeded, and it could hardly be expected that all experiment in such a large number would succeed with the test, particularly when it is remembered that few have had any experience in planting and cultivating sugar beets and that many, owing to short notice, had not the ground prepared the previous fall as it should be for sugar beets. Therefore, results will not be found from all who received seed.

Particulars given above regarding the individual beet patches, noted at the time of the third inspection, between August 22nd and September 7th, will be interesting and instructive in connection with the table of results following later.

AYLMER EXPERIMENT.

Of the 52 Aylmer farmers to whom seed was given, 47 succeeded with the crop and only five failed, the latter by neglecting thinning and cultivation. The facts that 90% of the plots planted yielded crops, and that the few failures were due chiefly to neglect, make it perfectly evident that the sugar beet crop is at least as certain as any crop we grow. It is extremely important to have a properly prepared seed bed, and to plant only the earliest maturing and the best variety of seed.

Much the larger number at Aylmer planted early, between April 25th and May 5th; several planted later, one as late as May 18th, another even as late as June 7th; and two re-seeded, one on the 2nd, and the other on the 4th of June. The two re-seeded plots (34 and 48) and the one (51) planted on June 7th yielded crops much lighter than the average. Three of the plots (13, 32 and 51) were not planted strictly as required for factory purposes. The beets of 32 particularly were grown too far apart; consequently grew large, yielded less per acre, and were inferior in quality. The beet juice of these three averaged only 11.1% sugar, and 75.3 purity; while that of the 44 plots of beets grown as directions required averaged 14.4% sugar and 86.1 purity. Considering the farmers' inexperience in growing factory beets and their long practised methods of cultivating fodder roots, which methods produce inferior and unprofitable sugar beets, Aylmer has reason to be proud of the above results.

Averages on five different dates of all samples.

Date of pulling samples.	Clean beet.	Analysis of juice.	
		Sugar.	Purity.
September 20th.....	16.4	14 8	84.2
October 4th.....	17.4	13.9	83.5
October 18th.....	17.9	14 4	85.9
November 1st.....	18.6	14.2	86.5
November 15th.....	20.8	13.9	86.8

The difficulty of handling beets in cold frosty weather has been advanced as an argument against the beet sugar industry in Ontario, but the results of our experiment, as seen in the above averages, show that the average per cent. of sugar was highest on September 20th; and, except on October 4th, purity steadily improved through the season. These facts appear to indicate the probability that our bright, warm, summer weather and cold autumn nights mature our sugar beets early, making it possible, and also advisable, should factories be established, to begin delivering our crop early in September, in which case the entire crop could be lifted in pleasant weather.

To obtain the best results in sugar beet cultivation for factory purposes, there must be regular rapid growth during the summer months, with maturity of beets at time of lifting, which, to accomplish, requires warm, showery weather, particularly in early summer, and clear weather with cool nights in autumn. Such weather conditions did not prevail in the Aylmer districts last summer; on the contrary,



Figure 11 shows Mr. Cole's plot three months after planting, or two months later than Fig. 1. (See page 4) Mr. Cole stands in the background holding a beet in his hand.

May, June and July were very dry months; and, though the early part of September was fair, warm showery weather prevailed from September the 20th until after the last samples were lifted on November 15th. It cannot, therefore, be said that the excellent results of the Aylmer Sugar Beet Experiment are due to a favorable season, which was not the case.

WELLAND EXPERIMENT.

Owing to favorable seeding weather and to lack of farm help, the previously mentioned meeting at Welland, on the 28th of April, was attended by only a few farmers. Many who had intended taking sugar beet seed, being hard pressed with regular farm work, changed their minds. I found it necessary, therefore, to seek other farmers who would accept and plant the seed which was not taken by those whose names were on the list of applicants, but who for one reason or another had decided not to plant. These changes in the placement of seed operated to the disadvantage of the Welland experiment. The directions for cultivation not being carefully followed by a few, several unnecessary failures occurred. Fifteen out of fifty-two who received seed did not obtain crops owing, in some instances, to not planting, in others to wrongly prepared seed bed, and in others to drying and crusting of the surface soil. Five out of the list of thirty-seven who planted and obtained crops did not strictly observe directions for cultivation to produce factory beets, which, to be profitable to the manufacturer and therefore to the farmer, must have average or more than average purity. The average for the whole season of the beet juice of these five beet patches (16, 30 41, 43 and 52) was only 11.5 per cent. sugar and 77.3 purity, while that for the whole season of the best juice of the 32 properly cultivated patches was 14.7 sugar and 85.4 purity.

Averages on five different dates of all samples.

Date of Pulling Samples.	Clean Beets. ozs.	Analysis of Juice.	
		Sugar.	Purity.
September 20th	15.7	15.1	82.5
October 4th	16	13.7	82.8
October 18th	19.9	14.2	85.9
November 1st	16.5	14.3	85.4
November 15th	17.2	14.4	84.9

It is also true of beets grown in the Welland experiment, as the above averages show, that the first samples, collected on September 20th, averaged the highest in sugar. The numbers showing average weight of clean beets indicate very little increase in size from September 20th to November 15th. That Welland beets are a little small, is not, when the reason is understood, a discouraging feature. In answer to the question, "Were rainfall and growth average in your district this past summer?" Mr. John H. Hennings, Asst. Inspector in the Sugar Beet Experiment at Welland, writes, "No. We had the driest season I ever experienced in this country in eighteen years." He further adds, "I think it will be little trouble in a fair season to grow 18 to 20 tons per acre. I have 170 big bushels on the quarter acre, and very nice roots. In fact I am very pleased with them, and all those who have grown them will, I am satisfied, do so again on a larger scale." The four other Assistant Inspectors in the Welland Experiment answered the above question with regard to rainfall and growth to the same effect, namely, that the early summer was extremely dry. That the results in both yield and quality of beets in the Welland Experiment were obtained under such adverse conditions as the above is certain evidence of the adaptability of the district to sugar beet cultivation.

NEWMARKET EXPERIMENT.

In the Newmarket Experiment seed was given to forty-five farmers, practically all of whom closely followed directions for cultivation, and succeeded with the

crop. That such is the case is very creditable to the farmers in the Newmarket district, for the reason that previous to the day of the initial meeting, May 9th, few, if any, had given any thought to the subject.

That the soil of the Newmarket district will yield beets of a uniformly high quality is made perfectly evident by the above results.

As in the former experiments, namely, those at Aylmer and Welland, the above averages show that the beets were richest in sugar on the first day of collecting samples, September 25th; that there was very little increase in the size of beets between that date and November 6th. Purity, however, though always high, gradually improved. It is quite possible, as at Aylmer and Welland, that the delivery of a crop at a factory could be profitably commenced early in September, owing to the favorable influence of our climate in maturing sugar beets at a very early date.

Averages of four different dates of all samples.

Dates of pulling samples	Clean beets. OZS.	Analysis of juice.	
		Sugar.	Purity.
September 25th	17.3	15.3	81.9
October 9th	17.7	14.7	81.2
October 23rd	19.6	14.2	84.0
November 6th	19.7	15	84.1

COST AND PROFIT OF SUGAR BEET CULTURE.

In considering the cost and profit of sugar beet culture in Ontario, the following clipping from "Progress of the Beet-sugar Industry in the United States" contains interesting information:

PROGRESS OF THE BEET-SUGAR INDUSTRY IN THE UNITED STATES.

Report of Special Agent Charles F. Saylor, to the Hon. James Wilson, Secretary of Agriculture, U. S. Department of Agriculture, Washington, D.C., dated May 11th, 1899.

CHANGED CONDITIONS. In reporting on the progress made in the development of the beet-sugar industry in the United States, I will first call attention to the changed conditions under which this work has been prosecuted.

Most of the States that have hitherto entered into the experiments in growing sugar-beets have been pursuing this line of investigation for several years. The results have been published annually in the bulletins of the State experiment stations. In most cases the investigations have been exhaustive; in some it has been demonstrated that the States have the natural conditions for growing sugar beets and manufacturing sugar from them; in others it has been shown that conditions are not favorable for growing sugar beets for factory purposes. Many of the States, upon the showing made, have not thought it advisable to continue this line of investigation any further, but have felt content to call attention to the facts already shown. In States where these facts were favorable for the establishment of the beet sugar industry, the energies of the States have been turned in the direction of encouraging the establishment of factories by interesting capital and promoting organizations, which is as important as any part of the work. Under these circumstances, my attention and efforts have been largely directed to investigating existing conditions. I have visited beet-sugar

organizations and attended public meetings in localities where considerable interest was manifested in this enterprise, furnishing such aid in the way of information as seemed advisable, in public and private talks, newspaper interviews and the like. These visits have been to all sections of the United States where it seemed most could be accomplished.

A number of new factories will be established, ready for the campaign of the present year. Several others will be commenced this year with a view to completing them in time for next year's campaign. In quite a number of communities throughout the United States the propriety of organizing companies and building factories is receiving serious consideration, and the probabilities are that a number of new factories will be built in the near future.

THE FARMERS' INTEREST IN THE INDUSTRY. I can report considerable progress in the development of public interest in the beet-sugar industry. The agricultural press, the secular press, and writers and lecturers on agricultural subjects have devoted considerably more space and attention to the subject during the past year, and the general public is much better informed with reference thereto than it was a year ago. Among the important causes for the increase of interest among farmers the following may be stated :

SUGAR BEETS IN CROP ROTATION. The major part of the preparation of the soil can be done in the fall, giving weed and grass seeds a chance to germinate and thus be destroyed, and giving the soil a better chance to become mellow and friable through freezing. But the main and most beneficial effect of a sugar-beet crop in a rotation is the excellent condition in which it leaves the soil for following with any other crop. The deep plowing required, the necessarily intense cultivation employed, and the clean condition in which the ground is left will show their good effects on the land for several seasons.

Farmers throughout the sugar-beet regions fully understand and appreciate the great benefits from growing sugar beets. Experience teaches them two things clearly : (1) The beet crop will pay the expense of this intense cultivation ; (2) all crops are materially benefited by this good cultivation. Many farmers successfully grow sugar beets following corn, and, in fact, it is as good a practice as any, if not the best, when possible. It takes only a little more work to prepare the ground, and the beet crop gets the benefit of the cultivation of the land during the previous year.

We have only to investigate the conditions prevailing in localities that are limited to one or even two kinds of crops to see the disadvantage of limited crop-resources. Sugar beets add an important crop to the already extensive resources of the Mississippi Valley.

RELATION OF SUGAR BEETS TO STOCK FEEDING AND DAIRYING. There is no better settled proposition than that the manufacture of beet sugar affords an opportunity for establishing these industries on the most economical and successful basis. The beet pulp is a cheap food, and in a food ration gives results not attained by any other element entering into any other ration. This comes not so much from the inherent nutrition of the pulp as from its ability to make the most of the other food eaten by the animal, making available the nutrition in the ration as a whole. I have been advised by some of the largest and most successful stock feeders in the country, after extensive experiments made by themselves, that, with pulp as part of the ration, they were able to put steers on the market in three-fourths of the time, using the same amount of grain daily as is ordinarily fed ; and it is the universal verdict of dairy feeders that no other kind of ration produces nearly such results as one containing sugar beet pulp. I have seen whole valleys on the coast covered with the dairy industry and milk trains running to San Francisco, where nothing of the kind existed before the introduction of the pulp, and where they were not possible without it.

MONEY RETURNS AND OTHER BENEFITS. Instead of crude material, the farmer should furnish as nearly as possible finished products. This principle applies to

the beet sugar industry. In no other direction has a large area of this country, East, North, and West, such inviting prospects; especially is this true of the Mississippi Valley. It seems that we are destined to clip our wool and send it to New England where the busy hum of the factory transforms it into useful textures to clothe ourselves and the rest of the world. The native of Iowa, for instance, passes through the various stages to manhood and down the decline, and his ears may never have heard the music of the spindle. The beautiful finely-developed cattle from the meadows and pens are sent away and returned as beef prepared for the table, thus diverting the bulk of the profits to others who have contributed very little to the production, and preventing the advantages which would result from having the work done by local labor and capital. But here is a chance in the sugar industry to see the factory and farm side by side, working to produce one of our articles of food and luxury. Here is a chance to hear the hum of industry, the music which thrills and inspires the soul of man, brightens and gladdens the home, amalgamates and develops our social organism. We look out and see those restless volumes of smoke issuing from chimneys early in the morning and late at night, denoting that our own coal, mined by our own people, is working up a product of our farms in a factory manned by our own laborers, who buy of us the necessities of life, and we feel compensated to some extent, in spite of the fact that many of our other crude materials are compelled to seek manufacture in other sections of the country.

But this is not the only compensation. We must consider the direct benefits to the farmer of growing sugar beets for the factory. It has been my province during the last three years to visit all of the beet-sugar sections of the United States, where beets are being grown on a large scale and sold to the factories, and I can speak from actual observation in regard to the benefits. Of course, beets grown in different parts of the United States are grown under different conditions, which will affect, to some extent, the cost of production and the profits incident thereto. Speaking conservatively, I shall lay down some general facts which will give an idea of the average profits to the farmer in sections of country where beets are produced under rain conditions, and where the cultivation is similar to that which would be necessary in Iowa, for instance. A fair estimate of the cost of producing sugar beets in Iowa would be about \$30 per acre. This allows for every element of cost entering into the production of the beets. It allows a farmer \$2.50 a day for himself and team, and the laborers whom he may employ \$1.50 per day. A great deal of the work can be better done by boys from 12 to 16 years of age at a somewhat reduced rate. The universal price of sugar beets at the factories in the different parts of the United States is \$4 to \$4.50 per ton, but I will use the minimum price of \$4 in making this calculation. My investigation of the production of sugar beets in other localities leads me to say that Iowa can readily produce from 12 to 15 tons per acre on an average. Of course, some years under extraordinary conditions some farmers might produce as high as 25 tons an acre. I have known of even larger yields than that. Some years under poor crop conditions some farmers may produce as low as 5 or 6 tons to the acre, but these would be extremes in either case. Going back now to our average, the farmer that produces 12 tons per acre receives \$48 per acre for his crop, or \$60 on a crop of 15 tons. His profits over and above all expenses would be \$18 on the smaller, or \$30 on the larger crop. Of course, the farmer that produced 25 tons per acre would have an enormous profit, namely, \$70 per acre, or enough to buy the best land in the State of Iowa. I know of no other single product which can be grown on the farm to any considerable extent that will compare with this.

Farmers are inclined to look too much at the element of cost, and say that \$30 is a snug sum of money to pay for producing an acre of anything; but they should consider this as they would any other business proposition. Will the profits justify such an outlay? If so, the proposition to raise sugar beets is a good one. Before the farmer can produce fattened steers to any great extent he must make an investment in the stockers. And is it not a fact that, after making such investment, he

is not nearly so highly compensated as he would be if he made the same investment in labor and expense necessary to produce sugar beets? Doubtless the experience of each farmer himself will be the best answer to this question. I may make the same illustration with the dairy cow. Before he can go very extensively into this business the dairyman must first buy the cows and build his barn. He does this because he figures that he is going to be a gainer thereby, and that is the one basis upon which the farmer should settle the question of raising sugar beets.

I have studied very carefully the history of the starting of all the factories in this country, and without exception it has been difficult to get the farmers in the beginning to contract to raise the beets, but after an experience of one or two years it ceases to be a question as to who can be induced to sign the contracts, and becomes a question among the farmers as to who can secure the contracts.

Another beneficial feature of the sugar factory in a community is that an outlay of \$30 to produce an acre of sugar beets means a large outlay for labor in the vicinity, as the large expense of producing beets is for labor. In case of a town of several thousand inhabitants and the community surrounding, it is a fact that everyone who wants work can get it, and I believe it to be true that savings banks in towns where factories are located have a larger number of depositors than in other places on account of the large amount of labor involved in the production of the beets and the manufacture of the sugar. When we consider that the money secured for the finished product comes back almost entirely to the community in which the factory is located, we begin to see the blessing of a sugar factory. This money goes for coal, for labor, for transportation, for limestone, and many other crude materials. About the only thing taken away by the people controlling the factory is the profits, and if it happens to be a factory that is organized by local people, then the profits themselves remain to enhance the riches of the community."

CULTIVATION IN ONTARIO.

It may be several years at least before Ontario farmers will be in a position to give an exact estimate of the cost of the production of an acre of sugar beets. In the first place farmers have to learn a good deal about the kind of cultivation required and, in the second place, they will have to learn how to economically accomplish that required cultivation. In these sugar beet experiments our farmers were asked to cultivate as follows:

FALL CULTIVATION. If the beets follow fall wheat, the land may be plowed shallow, just covering the stubbles as early after the wheat is harvested as possible and harrowed, causing the vegetable matter to decay and seeds to germinate. Late in autumn, cross-plow to a depth of nine inches, following in each furrow with a subsoil plow, loosening (not turning up) the soil several inches deeper. Leave the land, thus plowed and loosened, to the winter frost, which through alternate expansion and contraction, becomes disintegrated and mellowed. But in case potatoes or fodder corn precede the beets, early autumn cultivation of the potato ground should not be necessary, while that of the corn land may be modified for the purpose of disposing of the corn roots. Late deep plowing is an essential part, however, of fall cultivation of sugar beets on any soil; but subsoiling, as above described, may be omitted in exceptional instances where the subsoil is naturally free and open.

In case it has not been practicable to apply farm-yard manure to the crop preceding sugar beets, then the manure should be drawn out upon the stubble land and just covered by the early autumn shallow plowing which is mentioned above.

SPRING CULTIVATION AND PLANTING. Plant as early as climate and soil will allow. Early planted beets, as experience in other countries has shown, uniformly give both a greater yield and a higher content of sugar than those which are planted later.

Spring cultivation for planting must be shallow, the object being to prepare a seed-bed whose soil is reduced to the highest degree of tilth, resembling the surface soil of a well prepared onion bed. The exact method of working the land to obtain this object will vary in different locations and soils as soils themselves and weather vary. For every soil however, loosening the surface to a depth of three inches is an essential operation, after which, by the proper use at the right time, of the roller and harrow, a seed-bed, which is mellow, firm, moist and warm, can with little difficulty be prepared. The seed should be planted upon the same day, or as early after as possible, as the final preparation of the seed-bed.

CULTIVATION OF BEETS BEFORE THINNING. As soon as the plants can be traced in the row, surface cultivation of the soil between the drills should be commenced, to clean the land and preserve moisture, to admit air more freely into the soil, and in every way to hasten the most rapid growth of the young plants.

THINNING. After the first cultivation the young plants grow rapidly, when, upon the development of the 3rd or 4th leaf, thinning must be commenced, and should be finished as soon after as possible. Thinning is done chiefly with a narrow hoe, but the hands must be also freely used in singling out, for the reason that the young selected plants, unlike turnips, must not be roughly handled.

CULTIVATION AFTER THINNING. During thinning, the beets will have grown considerably, and the time having arrived for a second cultivation, the hand or horse hoe may be run deeper than in the first cultivation, in order to open thoroughly and loosen the soil for the free admission of air. A second hand-hoeing soon after finishing the first thinning is advisable, for the reason that two or more plants growing together injure one another both in size and quality. It has also the advantage of cleaning and loosening the ground in the drills between the plants. Even a third and a fourth horse hoeing may be done, depending, of course, upon circumstances. Every cultivation promotes growth, improving the chances for a profitable crop, but must never be done when the ground is wet.

While the above fall cultivation naturally could not be given in these experiments, commencing as they did after the season for fall cultivation had passed, spring cultivation, planting, thinning, and summer cultivation, as given above, were, by most of the farmers who grew beets in these experiments, faithfully and cheerfully followed.

YIELDS AND FINANCIAL RESULTS OF EXPERIMENTS.

AYLMER EXPERIMENTS.

Experimenter's number.	Per cent. Tare	Net yield per acre.		Net amount received.	Cost of crop per acre.	Net profit.	Experimenter's number.	Per cent. Tare.	Net yield per acre.		Net amount received.	Cost of crop per acre.	Net profit.
		Tons.	Pounds.						Tons.	Pounds.			
1	20.5	22	1,300	\$ 101 92	\$ 39 40	\$ 62 50	28	9.7	13	1,600	\$ 62 10	\$ 23 40	\$ 38 70
2	18.4	16	875	65 75	12 40	53 35	29	12.0	18	1,464	84 29	24 40	59 89
3	19.2	13	1,750	58 96	24 40	34 56	30	13.1	15	250	68 06	24 65	43 41
4	16.6	17	250	68 50	30 40	38 10	31	20.0	12	83	54 18	28 40	25 78
5	26.7	26	750	112 09			32	18.3	12	1,826	38 72	22 90	15 82
7	26.3	11	1,000	51 75			33	16.8	30	581	143 87	26 40	117 47
8	20.3	21	1,079	91 54	28 90	62 64	34	14.2	14	913	61 44	30 40	31 04
9	21.0	22	1,166	101 62			35	14.2	17	1,000	78 75	37 40	41 35
10	20.0	11	250	64 50			36	16.8	23	1,900	107 77	30 40	77 87
11	4.2	25	1,832	110 14			38	17.6	16	1,000	73 37		
12	24.7	16	750	69 59			39	11.1	20	500	91 12	35 90	55 22
14	19.3	17		72 55			40	17.6	22	581	94 73		
15	25.0	10	1,166	44 97			41	15.3	17	250	72 78		
16	21.0	22	1,500	96 68	27 40	69 26	42	14.3	12	666	55 49		
17	16.2	21	750	90 84			43	12.6	17	250	77 06	30 90	46 16
18	15.9	11		46 75			44	17.6	16		72 00	19 40	52 60
19	13.2	16	1,555	79 69			46	9.2	24	1,166	115 76		
20	10.0	21	500	90 30	19 40	70 90	47	14.9	28	166	112 33		
21	22.0	27	333	108 66	20 15	88 51	48	13.7	13	459	56 22	29 40	26 82
22	21.3	17	1,250	77 90	25 40	52 50	49	10.7	14	1,332	63 08	31 40	31 68
23	20.4	13	1,588	55 17	24 40	30 77	50	17.4	24		96 00	30 90	65 10
24	19.5	26	1,000	112 62	20 40	92 22	51	17.1	10	62	40 12		
27	21.9	21	1,125	80 85	59 90	20 95	52	18.7	20	1,500	88 18	26 65	61 53

WELLAND EXPERIMENT.

Experimenter's number.	Per cent. Tare.	Net yield per acre.		Net amount received.	Cost of crop per acre.	Net profit.	Experimenter's number.	Per cent. Tare.	Net yield per acre.		Net amount received.	Cost of crop per acre.	Net profit.
		Tons.	Pounds.						Tons.	Pounds.			
1	19.92	13	500	\$ 59 62	\$ 29 90	\$ 29 72	26	15.44	12	1,750	\$ 57 93	\$ 30 15	\$ 27 28
2	16.19	14	1,332	62 33	28 70	33 63	27	15.48	14	166	63 37	36 90	26 47
3	25.95	14	1,332	66 00			28	15.45	20	1,166	82 33	35 90	46 43
4	24.38	13	1,518	58 47			29	24.63	15	333	68 25	37 40	30 85
5	17.14	24	83	90 15	25 90	64 25	30	16.50	24	83	78 13	33 40	44 73
6	25.29	6	1,600	28 90			31	27.78	9	833	44 73	23 40	21 33
7	20.29	11	777	51 25			32	19.41	10	150	47 85		
8	22.78	13		58 50			33	14.55	9	1,500	41 43		
9	16.78	13	500	62 93			34	14.09	15	500	64 81	23 15	41 66
10	22.75	14	1,200	69 35	33 40	35 95	35	19.62	13	334	62 54	25 40	37 14
11	23.47	12	500	55 12	41 15	13 97	37	19.10	9	500	41 62	23 90	17 72
12	16.76	12	666	58 58	66 15		41	27.78	22	500	72 31	45 40	26 90
14	18.98	11	1,000	48 87	25 40	19 47	43	15.31	13	1,332	51 24	25 90	25 34
16	21.48	6	833	27 27	20 90	6 37	44	10.07	21	1,000	86 00	19 65	66 35
17	15.68	12	1,000	56 25	26 90	29 35	45	17.08	12	444	51 94	22 40	29 54
23	19.29	14	1,000	56 20	36 75	19 45	48	14.70	4	1,000	19 12	23 40	
24	20.76	17	833	78 37	24 40	53 97	49	21.64	16	1,750	67 50	25 65	41 85

NEWMARKET EXPERIMENT.

Experimenter's number.	Per cent. Tare.	Net yield per acre.		Net amount received.	Cost of crop per acre.	Net profit.	Experimenter's number.	Per cent. Tare.	Net yield per acre.		Net amount received.	Cost of crop per acre.	Net profit.
		Tons.	Pounds.						Tons.	Pounds.			
1	26.4	13	1,166	\$ 57 72	\$ 34 90	\$ 22 82	25	20.93	16	83	\$ 76 19	\$ 25 40	\$ 41 79
3	31.71	14	1,000	61 62	24 40	37 22	26	20.58	19	166	90 64		
4	16.35	18	83	81 18	26 15	55 03	27	19.42	16	830	73 86	30 85	43 01
5	14.29	21	333	89 95	24 30	65 65	29	17.58	13	1,000	67 50	19 40	42 10
7	13.74	25	833	108 02	35 50	72 52	30	15.32	19	1,150	92 98	18 30	74 68
8	19.73	24	1,000	91 87	30 50	61 37	31	16.43	14	200	66 97	29 45	37 52
9	16.67	11	833	51 37	30 50	20 81	32	16.02	17	1,332	83 91	24 90	59 01
13	15.29	16	1,332	70 83	17 90	52 93	33	13.28	10	333	48 29	24 90	23 39
14	10.75	19	1,600	94 05	42 90	51 15	34	12.63	17	1,332	70 66		
15	4.84	20	1,663	98 94	24 90	74 04	35	14.00	8	1,400	36 97	25 40	14 57
16	26.44	13	500	62 93	30 90	32 03	36	14.95	18	1,000	78 62	27 40	51 22
17	26.25	21	1,400	92 22	28 40	63 82	37	15.33	15	1,000	69 75	11 40	58 35
18	14.29	24	500	109 12	26 90	80 22	38	31.35	25	913	101 82	23 90	77 92
19	18.00	17	.....	68 00	39 90	28 10	39	14.7	19	1,166	83 22	24 90	58 32
20	12.86	13	1,411	58 24	24 40	33 84	40	20.74	23	1,555	101 05	33 90	67 15
22	29.79	13	1,330	44 41	.....	.....	42	20.15	12	1,909	55 05	19 40	35 65
23	23.22	13	750	53 50	23 40	30 10	44	12.50	9	425	39 15	20 40	18 75
24	20.5	14	1,000	68 87	23 90	44 97	45	13.18	15	83	71 44	27 40	44 04

With the experience gained by the cultivation of one crop of sugar beets, our farmers are able, at least, to speak more confidently about the cost of growing beets than they could do one year ago. Many have furnished actual figures on the cost of cultivation exclusive of marketing. Those given below of Mr. J. M. Van Patter, Luton, Elgin Co., whose number is 33 under Aylmer Experiment, will serve as an illustration:—

COST PER ACRE OF A SUGAR BEET CROP.

1. What rent per acre would your farm command ?	\$4 00
2. Cost of sugar beet seed for each acre, 16 lbs. at 15c.	2 40
3. Cost per acre of fall cultivation.	3 00
4. Cost per acre of spring cultivation and planting.	2 00
5. Cost per acre of thinning sugar beets.	6 00
6. Cost per acre of summer cultivation.	3 00
7. Cost per acre of harvesting the crop, including throwing beets into piles or pits and covering with three to four inches of soil	6 00
Total	\$26 00

All sums on the cost of cultivation in the columns under "Cost of Crop Per Acre" have been based upon the same seven items as in the above by Mr. Van Patter.

It was quite impracticable in estimating yield of crop to weigh the whole crop of one-eighth or one quarter of an acre, for which reason I decided to select an average inside row, measure an exact distance of sixty or more feet, from which the Assistant Inspectors pulled all the beets, which they topped, brushed, weighed, etc., as explained under :

DIRECTIONS FOR PULLING TO ESTIMATE YIELD.

As you are aware all the beets in a definite distance (60 to 180 feet, as may be chosen) of an average inside row are to be pulled, topped, and weighed for the pur-

pose of estimating the yield in tons per acre. In most plots, the row has been selected, and a distance or length of it from which the beets are to be pulled, marked off by two stakes. It will be your duty to check the distance between the stakes, owing to the fact that absolute justice is to be given to every experimenter. Should, for some cause, no stakes be found, you are to select an average inside row and stake off a fair distance from which to estimate the tons per acre. You will require an assistant, a barn scale, two baskets, two knives for topping, two spades, two strong brushes, and a tape.

You may select either the 25th, 26th, or 27th October as may suit you best for pulling to estimate yield.

The sugar beet experiment is a work of value to every farmer of the neighbourhood, and especially so to those growing beets. It is expected that the farmers upon whom you call to pull beets for the purpose of estimating yield will furnish you all the assistance possible, that your difficult task may be performed in the least time and at the least expense.

Check the distance between the two stakes in the selected row, which distance should be entered at once. Loosen all the beets without cutting off the tap roots in this distance of the row between the two stakes. Top by cutting off approximately that portion of the beet bearing stems and stem scars. Collect and weigh the beets and enter under "Gross Weight." The beets must then be brushed clean. All fibres, ends of roots less than one-quarter inch diameter, and any remaining portion of the crown must be cut off, after which the beets are again weighed and the weight entered under "Net Weight."

ESTIMATION OF TONNAGE.

Every Assistant Inspector was furnished with a blank form upon which all necessary entries were made at the time the beets were lifted. These filled-in forms were immediately forwarded to the Agricultural College, Guelph, and there the per cent. tare and net yield per acre, as given in the above table under Aylmer Experiment, Welland Experiment and Newmarket Experiment, were calculated.

The following form returned by Mr. Van Patter, as Assistant Inspector in the Aylmer Experiment, will serve to illustrate :

Experimenter's Number.	Date of Pulling.	Distance between stakes.	Distance apart of rows.	Gross Weight.	Net Weight.
	October.	Feet.	Inches.	Lbs.	Lbs.
21	25	60	21	168½	131
23	25	130	21	181	144
22	25	120	21	216	170
32	26	60	30	109	89
31	26	120	21	145	116
29	26	165	21	283	249
30	26	120	21	168½	146

Yields, as given under "Net Yield per Acre" in the three foregoing tables have been calculated from "net weights" received in the returns from the Assistant Inspectors who obtained these net weights by weighing, after topping, brushing, trimming, etc., all the beets lifted from measured distances of inside average rows as previously explained under "Directions for Pulling," to estimate yield. Figures 6, 7 and 8 show the same sample of beets, not topped, clean, and tared respectively. It is the tared beets, illustrated in Figure 8, for which the grower is paid. Many of the sugar beet contracts of the Michigan factories read, "The Company shall

accept and pay for beets containing 12 per cent. of sugar, \$4.50 per ton delivered in the storage sheds at its factory, and 33½ cents for every additional one per cent. of sugar." Our calculated "net amounts received per acre" in the Aylmer, Welland and Newmarket experiments are based upon \$4 per ton for beets containing 12 per cent. sugar, and 25 cents additional for every additional one per cent. of sugar. The calculated profits, therefore, are actually less than they would have been had the beets been delivered at a factory in the usual way.

AWARDING PRIZES.

Prizes being offered in each experiment, viz., Aylmer, Welland, and Newmarket, the results of every man's list, in which returns were full, have been scored. As explained in the introduction, a maximum of twenty was allowed at the first and at the second scoring. Sixty marks were divided between yield, per cent. sugar, and purity as follows: 30 for yield, giving one mark for each ton of tared beets; 15 for sugar, allowing one mark for each per cent., and 14 for purity, giving four for a standard purity of '80, and one mark for each increase of one per cent. in purity up to 90, but allowing nothing for purity below 80. To illustrate, take the case of 40 in the Newmarket experiment:

Second inspection	20
Third inspection	20
14.6 per cent. of sugar	14
Purity of 86	10
Yield of 23 tons, 1,555 lbs	23

Total out of a possible 100	87
-----------------------------------	----

The following, arranged in order of merit, have won prizes:

District.	Experimenter's number.	Experimenter's name.	Post Office.	—
Aylmer	33	Van Patter, J. M.	Luton	First.
"	11	Sisler, J.	Aylmer	Second.
"	16	Learn, C. O.	Aylmer	Third.
"	24	Gillott, J. M.	Copenhagen	Fourth.
"	46	Thompson, W. E.	Aylmer	Fifth.
"	9	Summers, G. A.	Aylmer	Sixth.
Welland	10	Stirtzinger, F. H.	Fenwick	First.
"	35	Cole, David	Southend	Second.
"	5	Taylor, Chas	Fonthill	Third.
"	11	Sloat, J. C.	Fenwick	Fourth.
"	7	Van Every, S. H.	Ridgeville	Fifth.
"	17	Stirtzinger, Philip	Fenwick	Sixth.
Newmarket	40	Ashley, B.	Newmarket	First.
"	7	McDonald, D. C.	Ravenshoe	Second.
"	18	Roode, G. W.	Holland Landing ..	Third.
"	15	Brammer, A. E.	Newmarket	Fourth.
"	45	Starr, M.	Pine Orchard	Fifth.
"	14	Wright, James	Newmarket	Sixth.
"	16	Lundy, C. E.		

AYLMER SCORE.

Experimenter's Number.	Second Inspection.	Third Inspection.	Sugar.	Purity.	Yield.	Total.	Experimenter's Number.	Second Inspection.	Third Inspection.	Sugar.	Purity.	Yield.	Total.
1	15	19	15	11	22	82	28	18	18	15	13	13	77
2	12	11	13	9	16	61	29	15	15	15	11	18	74
3	14	20	14	8	13	69	30	19	19	14	13	15	80
4	15	17	13	8	17	70	31	15	15	15	14	12	71
5	16	15	14	9	26	80	32	12	13	9	...	12	46
7	15	6	15	12	11	59	33	18	20	15	11	30	94
8	16	16	14	9	21	76	34	14	13	14	9	14	64
9	15	20	15	11	22	83	35	18	20	15	11	17	81
10	16	9	12	11	16	64	36	14	19	15	10	23	81
11	19	20	14	11	25	89	38	18	18	16	10	16	78
12	19	20	14	10	16	79	39	12	18	15	11	20	76
14	13	17	14	11	17	72	40	17	19	13	7	22	78
15	18	16	14	10	10	68	41	20	20	14	11	17	82
16	20	20	14	10	22	86	42	16	13	15	10	12	66
17	18	17	14	9	21	79	43	18	19	15	8	17	75
18	17	18	13	8	11	67	44	17	18	14	9	16	74
19	18	20	15	10	16	79	46	16	20	15	8	24	83
20	10	16	14	9	21	70	47	18	18	13	4	28	81
21	13	18	13	7	27	78	48	15	19	14	13	13	74
22	16	18	14	11	17	76	49	14	6	14	9	14	57
23	16	8	13	7	13	57	50	12	19	13	8	24	76
24	16	19	13	10	26	84	52	17	17	14	6	20	74
27	16	19	12	6	21	74							

WELLAND SCORE.

Experimenter's Number.	Second Inspection.	Third Inspection.	Sugar.	Purity.	Yield.	Total.	Experimenter's Number.	Second Inspection.	Third Inspection.	Sugar.	Purity.	Yield.	Total.
1	17	13	15	10	13	68	26	17	5	15	9	12	58
2	18	17	18	7	14	69	27	15	10	15	10	14	64
3	19	16	15	10	14	74	28	16	15	13	5	20	69
4	19	14	14	9	13	69	29	9	9	15	10	15	49
5	18	19	12	5	24	78	30	16	10	9	...	24	59
6	14	14	13	9	6	56	31	17	13	16	10	9	65
7	18	19	15	12	11	75	32	18	18	15	12	10	73
8	15	18	15	8	13	69	33	10	4	14	4	9	41
9	15	18	16	12	13	74	34	11	3	13	5	15	47
10	18	20	16	12	14	80	35	19	19	16	11	13	78
11	19	19	15	11	12	76	37	12	18	15	12	9	66
12	17	14	15	12	12	70	41	16	15	9	...	22	62
14	16	9	13	9	11	58	43	13	12	12	...	13	50
16	9	9	13	9	6	46	44	18	19	12	4	21	74
17	19	17	15	12	12	75	45	17	18	14	7	12	68
23	19	19	13	8	12	71	48	4	3	14	8	4	33
24	13	18	15	9	17	72	49	16	17	13	8	16	70

NEWMARKET SCORE.

Experimenter's number.	Second Inspection.	Third Inspection.	Sugar.	Purity.	Yield.	Total.	Experimenter's number.	Second Inspection.	Third Inspection.	Sugar.	Purity.	Yield.	Total.
1	19	16	14	6	13	68	25	19	18	16	7	16	76
3	19	18	14	7	14	72	26	18	15	16	10	19	78
4	19	18	15	8	18	78	27	16	19	15	7	16	73
5	16	18	14	7	21	76	29	18	13	17	11	13	72
7	19	20	14	8	25	86	30	19	18	16	6	19	78
8	19	16	12	.....	24	71	31	15	16	16	11	14	72
9	19	19	15	10	11	74	32	17	17	16	8	17	75
13	16	16	14	9	16	71	33	19	17	15	10	10	71
14	16	18	15	11	19	79	34	18	11	13	.....	17	59
15	18	18	15	10	20	81	35	14	16	14	5	8	57
16	19	19	16	12	13	79	36	17	19	14	6	18	74
17	16	13	14	5	21	69	37	19	18	15	9	15	76
18	19	16	15	8	24	82	38	14	15	13	6	25	73
19	19	20	13	4	17	73	39	14	15	14	7	19	69
20	13	13	14	6	13	59	40	20	20	14	10	23	87
22	16	20	10	..	13	59	42	15	20	14	.....	12	61
23	15	19	13	4	13	64	44	15	11	14	5	9	54
24	18	17	16	9	14	74	45	18	19	16	12	15	80

SUGAR BEETS GROWN IN OTHER DISTRICTS IN ONTARIO.

In several other districts in Ontario, viz., Wiarton, Dunnville, Wallaceburg, Alvinston, London, and Sombra, sugar beets were cultivated last year, samples of which were forwarded to our laboratory for analysis. These beets, however, were not grown under my direction, and, therefore, I refer only briefly to them in my report.

Warton sent to our laboratory seven samples for analysis, a report of which I sent to W. D. Forrest, of the Warton Beet Sugar Mfg. Co., Limited, of Warton. Warton sugar beets, when properly cultivated, are of exceptionally good quality. The secretary of the above company, Mr. W. D. Forrest, reports that nine carloads delivered by farmers who had grown more than they required for feeding, were sold and shipped to a Michigan beet sugar factory. Some of these Warton beets brought 5.86 $\frac{2}{3}$ per ton at the factory, but the grower had to pay freight and duty. Dunnville sent six samples of beets to our laboratory, four of which tested below, and two above, the required standard of 12 per cent. sugar in beet and 80 purity. Wallaceburg sent two samples, one of which tested above and the other below the standard. Alvinston sent six samples, four of which tested below and two above the standard. London sent, in all, thirteen samples, five of which tested below the standard, and eight above.

The soil and climate of a district may be admirably adapted to the production of sugar beets of high quality, yet, by wrong methods of cultivation, feeding beets, which are always of an inferior quality, may be produced, entirely misrepresenting the capabilities of the district.

A five hundred ton factory was built last summer in Marine City, Michigan, but failing to secure sufficient acreage on the American side, the company in April last solicited acreage on the Canadian side of the St. Clair. Through the work of Mr. W. K. Snider, of Sombra, who engaged with the company, contracts to grow six hundred acres were signed, which acreage extended from a point below the town of Sarnia to Tupperville, on the east branch of the Sydenham, being in all a

distance of about forty miles. During the early summer there was on the part of the growers a want of confidence clearly manifested ; cultivation was more or less neglected, and in not one instance was thinning properly done. Mr. Snider, however, finally inspired the growers with sufficient confidence to encourage them to keep the patches clean and well cultivated. The entire crop, running from twelve to twenty-eight tons net per acre, and selling at the flat price of \$3.20 per ton at a Canadian point, was shipped. The growers realized for their crop from \$40 to \$90, with a probable average of \$55 per acre. The results of this year's experience have created among the growers a keen anxiety to renew their contracts with the company. Had the beets been delivered and sold at the factory, they, the growers, would have received \$4.50 per ton for beets testing 12 per cent. sugar in beet, with an addition $33\frac{1}{3}$ cents for every 1 per cent. of sugar over 12. The growers in this case would have had to pay 50 cents freight per ton, and 25 per cent. duty, amounting in all to \$1.30 per ton ; but they chose, however, the above flat price of \$3.20 per ton at the Canadian point of shipment, losing, thereby, the advantage of the additional $33\frac{1}{3}$ cents per ton for every 1 per cent. of sugar over 12. These beets tested at the laboratory of the sugar factory from 11 per cent. to 16 per cent. sugar in beets, with a purity of 80 and upwards. Mr. Snider writes ; "The principal cash outlay in raising the crop is the cost of thinning and topping. We grew ten acres on our own farm this year, and find that these two operations can be performed for \$10 per acre. The rest of the work is done by horses, and is controllable by most farmers. We use a beet puller or lifter for pulling the beets ; it is a simple, durable implement and works perfectly. A pair of very light horses will easily pull three acres per day. We have thoroughly tested our district, and find it pre-eminently adapted in every way to the growing of beets, and we are making every effort to bring about the establishment of a factory in our midst."

CONCLUSION.

The results in yield, in quality, and in cost of cultivation of sugar beets, make it perfectly evident that Ontario farmers, in certain extensive districts in the Province, can realize comparatively large profits by growing sugar beets at the prices paid for them by American beet sugar factories. Undoubtedly the beet sugar industry once established in Ontario will prosper. Our soils are, for the most part, quite suitable to the cultivation of sugar beets ; the warmth and the bright sunshine of our early summer are favorable to the production of size of root and sugar ; while the bright days and cool nights of autumn insure at an early date a high degree of maturity. We have in our Province abundance of water, and in many places extensive limestone deposits. Ontario Farmers through the helpful instruction of the Ontario Agricultural College, the meetings of the Farmers' Institute, the Live Stock, the Dairymen's, the Fruit Growers' Associations, etc., have attained a well deserved and world-wide reputation for the high quality of their exported agricultural products. Farmers who by their intelligence, close observation, industry, and application of the most skilful methods, have won this reputation, can be depended upon to apply these same qualities in the development of what promises to be in this Province, one of our most important industries.

THE BEET SUGAR INDUSTRY IN MICHIGAN.

Owing to the proximity of the State of Michigan to that extensive and fertile southwestern portion of our Province bounding the north of Lake Erie, and where sugar factories, if established in Ontario, will probably be located, and owing to the extensive and valuable experience of that State in the establishment of beet sugar factories, the following clipped from Mr. Charles F. Saylor's Report to the Department of Agriculture at Washington, D.C., contains information of great practical value to this Province.

In recent years Michigan has been among the foremost of the states agitating this question. Probably no State in the Union has given more attention to scientific experimentation in order to arrive at a correct understanding of the conditions of the State. The State experiment station at Lansing conducted experiments all over the State, sending out seeds and information as to the best methods of planting, cultivating and harvesting. At the close of the season the station systematically analyzed specimen beets from each farmer's plot, ascertaining the sugar content and purity of the beets grown in the various sections. The experiment station has covered an enormous amount of work of this kind and published the results, so that the public might be generally advised as to the condition of the State of Michigan in all its various sections for growing sugar beets, and also the conditions that obtain in the State for manufacturing them into sugar.

These conditions are peculiarly favorable for several reasons: The State has an intelligent, active farming community: the soils appear adapted to growing sugar beets; the sugar content and purity of the beets ran very high throughout the experiments of several years. Michigan has an abundant supply of cheap fuel in her coal deposits; a good quality of limestone is easily accessible; large market centers are near, which will make a sure demand for the product; there are competing railroads, with probably as low freight tariffs as are enjoyed by any section of the country. In addition to this there is water transportation to some of the large trade centers, such as Chicago, Milwaukee and Detroit.

In addition to these numerous positive inducements to engage in the sugar industry in the State of Michigan, there was another, an incidental inducement, which probably exerted as much influence in this direction as any of the rest, and that was the waning of the lumber industry of Michigan. The State once sustained a large industry in the production of lumber of all kinds, but for a decade the saw-mills of Michigan have been curtailing their business or closing down on account of the diminishing supplies from the forests. In the last few years it has become a fact patent to everyone that the lumber industry of Michigan is fast coming to an end. This would leave a great deal of organized capital out of employment. The capitalists have been looking for some new industry which they could introduce into the State to fill the void. They were ready to extend to the sugar industry a welcoming hand.

The first factory to start was that of the Michigan Sugar Company of Bay City. This organization was induced largely by the results of experiments carried on by a temporary organization at Saginaw.

The experience of this factory during the fall campaign of 1898 induced the building of eight more factories in the State in time for the campaign of 1899. It seems probable that Michigan will have still others ready for the campaign of 1900. The factories built last year were those of the Bay City Sugar Company, Bay City; the Detroit Sugar Company, Rochester; the Wolverine Sugar Company, Benton Harbor; the Peninsular Sugar Company, Caro; and West Bay City Sugar Company, West Bay City; the Alma Sugar Company, Alma; the Holland Sugar Company, Holland; the Kalamazoo Sugar Company, Kalamazoo.

The nine sugar factories of Michigan started up, some of them being a little late, but all of them in time to work up the crop of beets grown. The results for the eight new factories were somewhat varied as to the degree of success attending the first year's operations. Some of these enterprises had been hurriedly organized and were late in beginning their construction, late in completing the same, and late in beginning their campaigns in the fall. Like all other new companies, they were compelled to accept whatever land was offered for growing the beets, and then in the fall were compelled to accept almost any kind of beets offered, because the supply was small. Some of these plants actually ran through the year without having anyone about the concern possessing any practical information about growing beets or getting them ready for the factory. They simply relied on what information could be gotten out of printed matter or conversation with those posted in some degree, and in this way their supply of beets for the first year's run was procured.

As said before, this was largely due to the hurried manner in which the organizations were effected, capital raised, and factories built. This kind of work necessarily furnishes a great deal of costly but valuable experience. These factories next year will be in a position to give much more attention to the agricultural side of the business. Farmers will be able to grow beets a great deal cheaper and very much better, and a better class of land will be called into requisition for growing the beets than was used in most places last year.

There are two legitimate criticisms that can be made on the growing of beets in Michigan in 1899. I examined a great many beet fields at nearly all the different factories in Michigan. There seemed to be a tendency to use the poorer quality of land instead of the best for growing sugar beets. It seems to be a common error in the minds of farmers who have not had experience in growing sugar beets that sandy ground must be selected for this purpose, and that regardless of whether it possesses any fertility or not. This error is given out in newspapers, public talks, and lectures, mostly by persons who have not had practical experience. This probably comes from the fact that, with most people in the Mississippi Valley, knowledge of sugar beet growing for factory use began in Nebraska at Grand Island and Norfolk, where all the soils in the vicinity are quite sandy. Much of the information that has been disseminated through the States east of Nebraska came through the experience of growing sugar beets in that State. But those interested in the industry in Nebraska have long since learned that they must call into requisition their very best soils, and that there are soils in other sections which are much superior to those on which sugar beets are grown about Grand Island and Norfolk. Barring black muck or waxy soils, the kind of soil that would be selected to grow a good crop of corn or potatoes is the kind that should be selected to grow a good crop of sugar beets. Of course, sufficient sand to prevent the soil from becoming hard and compact will help, but the fertility must be there. The soils in the State of Michigan, where the beets were grown last year for the factories, have been in use for some time and are pretty well exhausted. In introducing this new crop the State of Michigan will have to put into the business of growing sugar beets the very best soils she has, and in addition thereto she will have to resort more or less to a systematic course of fertilizing and rotation of crops. Another suggestion I would make in this connection is that the beets be planted in wider rows and farther apart in the row on these weaker soils than was done last year.

It cannot be said that the experience of the sugar-beet growers in Michigan last year was as a rule encouraging, but I think the experience of this year will be much more favorable. Climatic conditions were very bad last year; an excess of rain fell at a time when it was not needed, and the weather was excessively dry at a time when beets needed moisture most. It would be hard to select a year more unfavorable than last year in Michigan for growing sugar beets. In addition to this it was precipitating a heavy task on the farmers of Michigan to ask them to grow at once and for the first time sugar beets sufficient to keep in operation nine sugar factories during a campaign, and that in a section of the country where practically nothing was known about the art of growing sugar beets and where no organization had been effected to discover a class of labor educated and available for this purpose, so that practically the whole crop was produced by inexperienced and unprepared labor. I saw a field of 16 acres of sugar beets that had been nicely cultivated and kept clean and looked from the road to be in splendid shape. But on going into the field it was discovered that the field of beets had never been thinned. On talking with the farmer I found that no attempt had been made to thin them, as he did not believe it was necessary. The largest of these beets would probably weigh three-quarters of a pound, and they ranged from that down to the size of radishes. Here was a whole field of beets that would have given a beautiful stand if they had been thinned. It had been carefully cultivated and was free from weeds, but it was an absolute failure as a crop. The importance of thinning was not appreciated as a rule in Michigan. There was a tendency to leave beets in bunches, and this was enough to affect the whole amount of the crop seriously.

The best and most careful attention given to the growth of the sugar beets was at the Caro factory, and here I found the best beets grown in the State of Michigan during the season probably as good as could be grown under the circumstances, considering the weather and the fact that this was the first year for the soil and farmers in growing sugar beets. The success of the factory was due entirely, I think, to the selection of a capable and industrious farm superintendent who had had extensive experience in growing sugar beets, both in Germany and in the United States. I at one time examined his farm in Nebraska, where as a farmer he was growing 300 acres of sugar beets for the Grand Island factory.

All in all, the year has given the Michigan farmers and factory managers a great deal of experience, and consequently better results may be looked for in that State in 1900. I am confident that the sugar industry of Michigan has come to stay. The farmer is learning his part, and with this and last year's experience, will be able to furnish the factory with sufficient quality and quantity of beets, and with profit to himself. The stock raiser and dairyman will discover that a great impetus has been given their industries by this sudden introduction of large quantities of desirable and valuable yet cheap stock food in the sugar-beet pulp. I predict that this feature alone, when the benefits accruing to the agricultural interests of Michigan shall have been determined, will make a showing that will surprise the State. It will make it possible for Michigan to go into animal industries on a large scale, feeding beet pulp along with grain, and establishing dairies to produce milk, butter, and cheese for the near-by market centers. The State of Michigan during the last factory campaign produced 30,106,113 pounds, or 15,053 tons of sugar, made from 210,911 tons of beets, which yielded in addition 105,455 tons of pulp.

FACTORIES IN OPERATION.

The following is a list of the companies operating in the United States with their present daily capacity in tons of beets :

	Tons.
Alameda Sugar Company, Alvarado, Cal.....	800
Spreckels Sugar Company, Watsonville, Cal., formerly Western Beet Sugar Company	1,000
American Beet Sugar Company, formerly Chino Valley Beet Sugar Company, Chino, Cal.....	750
Los Alamitos Sugar Company, Los Alamitos, Cal.....	700
California Beet Sugar and Refining Company, Crockett, Cal. (also refines Hawaiian sugar)	500
Oregon Sugar Company, Lagrande, Oreg	350
Utah Sugar Company, Lehi, Utah :	
Main factory at Lehi	500 }
Slicing station, at Springville	350 }
Ogden Sugar Company, Ogden, Utah.....	500
Pecos Valley Beet Sugar Company, Eddy, N. Mex.....	200
American Beet Sugar Company, Grand Island, Neb., formerly Oxnard Beet Sugar Company	350
American Beet Sugar Company, Norfolk, Nebr., formerly Norfolk Beet Sugar Company	350
Minnesota Sugar Company, St. Louis Park, Minn	400
Michigan Sugar Company, Bay City, Mich	350
First New York Beet Sugar Company, Rome, N.Y.....	200
Binghampton Beet Sugar Company, Binghampton, N.Y.	350
Spreckels Sugar Company, Spreckels, Cal.....	3,000
American Beet Sugar Company, Oxnard, Cal., formerly Pacific Sugar Company	2,000
Union Sugar Company, Santa Maria, Cal.....	500
Washington State Sugar Company, Spokane, Wash	350

	Tons.
Colorado Sugar Manufacturing Company, Grand Junction, Colo.....	350
Standard Beet Sugar Company, Ames, Nebr.	500
Illinois Sugar Company, Pekin, Ill.....	700
Bay City Sugar Company, Bay City, Mich.	600
West Bay City Sugar Company, West Bay City, Mich	500
Peninsular Sugar Company, Caro, Mich.....	600
Detroit Sugar Company, Rochester, Mich	500
Alma Sugar Company, Alma, Mich.....	500
Kalamazoo Beet Sugar Company, Kalamazoo, Mich	500
Wolverine Sugar Company, Benton Harbor, Mich	500
Holland Sugar Company, Holland, Mich	350
Total capacity	19,100

FACTORIES BUILDING.

The following is a list of the companies now building factories in the United States, with the location and capacity of each factory. Most of them will take part in the campaign of 1900. One or two will not be operated until 1901.

	Tons.
American Beet Sugar Company, Rocky Ford, Colo.....	1,000
National Beet Sugar Company, Sugar City, Colo.....	500
Continental Sugar Company, Fremont, Ohio.....	400
Empire State Sugar Company, Lyons, N. Y.....	500
Utah Sugar Company, Binghampton Junction, Utah (auxiliary to Lehi)....	350
Marine Sugar Company, Marine City, Mich	350
Total capacity new factories.....	3,100

PROPOSED FACTORIES.

Under this head attention is called to beet-sugar companies already organized and which give every indication at this time of constructing their factories and having them ready for the campaign of 1900 or 1901.

The Fort Dodge Beet Sugar Company, Fort Dodge, Iowa.—Articles of incorporation have been filed. Capital, \$450,000: O. M. Oleson, president; W. T. Chantland, secretary. Most of the acreage desired by the company has been pledged by the farmers.

The Storm Lake Beet Sugar Developing Company, Storm Lake, Iowa.—This company has recently closed contracts for the total amount of acreage necessary for a factory at that place for the campaign of 1901. It was claimed that the factory was assured, provided sufficient contracts could be secured to grow the beets. These contracts are now all signed, and Storm Lake will probably be the first to start in the beet-sugar industry in Iowa.

The Farmers' Co-operative Beet Sugar Company, Dundee, Mich.—This company has decided to build a factory this year, and will begin early in the fall so as to have the plant completed by July 1, 1901. It is proposed to build a factory of 750 tons daily capacity.

Virginia Beet Sugar Company, Fredericksburg, Va.—This company has perfected plans for building a factory at the above place, either to commence work in the campaign of 1900 or 1901, depending upon circumstances. The project at this time seems quite likely to materialize.

The Northwest Beet Sugar Company, North Judson, Ind.—It appears that a company was organized to operate a beet-sugar factory at the above place under the name of the New England Beet Sugar Company. This company contracted with

the farmers for about 6,000 acres of beets, but for some reason failed to perfect its plans, and the Northwest Beet Sugar Company was organized for the purpose of carrying out these contracts and for operating a sugar factory at that place.

CONSUMPTION OF SUGAR IN THE UNITED STATES IN 1899.

The following is clipped from the Sugar Trade Journal :

The consumption of sugar in the United States for 1899 was 2,094,610 tons, against 2,002,902 tons in 1898, an increase of 91,708 tons, or 4.57 per cent. The consumption of 1899 consisted of 160,400 tons of domestic cane sugar, 79,368 tons of domestic beet sugar and 5,000 tons maple and other sugars, a total domestic production of 249,968 tons ; and 1,560,764 tons of foreign cane sugar, 272,943 of foreign raw beet sugar, and 5,935 tons of foreign refined, a total of 1,839,642 tons imported. * * * The amount of refined sugar which went into consumption in 1899 was 2,040,676 tons, of which the American Sugar Refining Company manufactured 1,385,608 tons, or 67.9 per cent.; the independent refiners, 585,765 tons or 28.7 per cent.; the beet-sugar manufacturers who make refined sugar, 63,368 tons, or 3.1 per cent., and the foreign refiners, 5,935 tons, or 0.3 per cent. The amount consumed in the raw plantation condition was 53,934 tons. The undisturbed stock of refined sugar we estimate at 20,000 tons, against 25,000 tons during last year.

LETTER FROM MR. JOHN L. FREESE, CARO, MICHIGAN.

When inspecting the beet fields in the State of Michigan last August, I asked Mr. Edmund Starke, Agriculturist to the Beet Sugar Company, with whom I was driving, to tell me the name and address of the proprietor of a farm containing a field of beets we were at the time passing, which appeared to be properly planted and cultivated. A few days ago I wrote Mr. Freese, the proprietor of this farm, that the beet sugar industry was being enthusiastically discussed in Ontario, and that I would like to know just what he thought of the sugar beet crop from a farmer's standpoint. The following reply was received :

Caro, Michigan, January 17th, 1901.

Dear Sir,—I received your letter of the 11th inst., and have noted contents. I find the beet crop the best crop by far of any we raise. I have grown beets two years. The first year was not so good as last, but it was a new business and also a bad season for beets. Last year I had four acres, and had 60 tons, 910 lbs. raw beets, and 3 tons, 219 lbs. out for tare. I received \$284.70 for my crop, which cost me in the neighborhood of about \$100 I will say to be safe. Now I think the beet crop will be the crop for a few years at least. Every one here is well pleased with their crop this year. This is as near as I can get to the answer you asked.

I am,

Yours truly,

J. L. FREESE.

P. O. Box 694.

BEET PULP.

The following quantities of digestible matter in 100 lbs. of beet pulp and of corn ensilage have been determined by the California Experiment Station—

	Beet Pulp.	Corn Ensilage.
Protein	1.3	1.4
Fat	0.4	0.6
Carbohydrates (sugar and starch, etc.)	4.2	5.6
Fibre	2.5	6.5

Herbert Myrick, in his valuable book entitled "Sugar ; a New and Profitable Industry," writes, "The pulp from beets after the sugar is extracted, makes an

admirable feed for all stock, horses, cattle, sheep, swine and poultry. Yet its value for this purpose is only beginning to be appreciated in this country, though in Europe the farmers would no more think of allowing beet pulp to go to waste than our farmers would think of curing hay for fuel. At the Utah factory, a Feeding Company has contracted for all the pulp for a series of years, and have erected adjacent to the factory a complete system of sheep and feeding pens. Two thousand head of cattle are fattened here each season for market. They eat the pulp greedily, consuming from 100 to 125 lbs. per head each day, besides about 15 lbs. of hay. These cattle command a very good market, the meat being very juicy and tender. The cattle fatten quickly under proper conditions, and as the company get the pulp for nothing, except the cost of removing it from the factory, the enterprise is a profitable one."

Having heard that beet pulp is fed extensively by the Feeding Station of the Standard Cattle Company, Ames, Nebraska, I wrote the General Manager, Mr. R. M. Allen, for information regarding the experience of his Company in feeding pulp, to which I received this frank and cordial reply :

AMES, Neb., Jan. 24, 1901.

DEAR SIR,—I am in receipt of yours of the 16th inst., and send you herewith a few copies of a publication, called *Wool Markets and Sheep*, in which we printed all we knew about the feeding of pulp to sheep in an experiment last winter.

We have between 30,000 and 31,000 head of sheep on feed of pulp, grain, sorghum, hay, &c., and begin making shipments to-morrow. The figures of this sheep feeding experiment will not be written up for a long time, so that we cannot give you any information regarding it, except that we have been feeding not more than one and one-half pounds of crushed corn per day to aged wethers, and from that down to a pound or less to lambs. The crushed corn is mixed with the pulp in the feed boxes, and in addition we feed sorghum-hay and other kinds of hay. For some time we have been passing the sorghum through a cutting machine in order to lessen the consumption of sorghum, as the price of hay is rather high this winter.

I am not able to tell you the feeding value of the pulp compared with turnips and mangolds. We have fed whole sugar beets or cattle beets, quite largely, but I do not think that any of us could say whether sugar beets or pulp is the more valuable. We never fed high grade sugar beets, of course, but regular forage beets and distillery beets from French seed. I rather think that the sugar beets are of more value than the pulp, but this is not a practical question for our purposes, as we obtain the pulp from our sugar factory without any charge, except the cost of switching charges to our sheep barn.

I made an experiment in feeding pulp to cattle during the winter of '92-3; this experiment was made in our cattle barn, since changed into a sheep barn. I was inclined to believe at that time that the cheapest beef I ever made was made with corn ensilage, pulp, and hay, although only a few of these cattle got fat enough to ship at the end of four months, and I began feeding them some grain, as previous to that time they had no grain except corn in the ensilage.

It certainly would have value to a farmer to whom the cost of feeding, teaming, etc., would not be a cash cost. Our men in actual charge of the sheep have steadily maintained from the last two years that they are certain that beet pulp is of very considerable value, but of how much we have not yet made up our mind.

Yours truly,

R. M. ALLEN, General Manager.

Mr C. G. Miller, a thoroughly practical and successful farmer near Caro, in Michigan, told me when I inspected his sugar beet field in August last, that he has quit growing other roots for feed, because he finds that beet pulp fully supplies the place of roots for feeding

Does beet pulp possess feeding value? is not a question in my mind at all. Sugar beets, like other roots, are highly digestible and have, in combination with other fodders, an intrinsic value beyond their apparent value as determined by analysis. Treatment with hot water to remove the greater part of the sugar does not injure the nutritive value of the remaining portion of the beet called beet pulp.

Statement of Sugar, raw and refined, imported into Canada in ten years ending June, 1880.

Countries whence imported.	Refined.		Raw.	
	Quantity.	Value.	Quantity.	Value.
	lbs.	\$	lbs	\$
Great Britain	300,269,780	15,596,843	7,277,169	312,587
United States	277,617,989	15,749,028	10,952,260	448,957
British West Indies	101,695,316	4,405,907	16,381,476	633,729
Spanish West Indies	155,638,596	6,702,585	39,701,739	1,436,504
Germany	4,001,701	188,205	.....	.....
Holland	388,793	28,615	.....	.....
British Guiana	4,911,857	226,414	1,117,139	35,842
Newfoundland	2,221,486	87,436	.....	.....
French West Indies	718,024	32,865	248,500	10,015
Belgium	3,711,389	229,875	2,292,204	108,596
Brazil	1,399,864	67,782	45,992,228	1,540,071
St. Pierre	96,195	4,629	.....	.....
Hawaiian Islands	3,250,273	203,956	1,005,127	50,196
Danish West Indies	1,132,858	47,062	27,106	1,106
France	24,775	1,503	.....	.....
Dutch West Indies	5,014	211	2,291,432	87,499
Dutch East Indies	7,795,747	282,012	2,382,749	84,381
China	90,524	3,506	.....	.....
Peru	820,334	38,288	147,760	4,407
Sandwich Islands	227,469	15,053	1,054,683	68,376
Spanish possessions in the Pacific .....	.....	.....	1,084,558	31,688
Total	866,017,984	43,911,775	131,956,130	4,853,954

Statement of Sugar, raw and refined, imported into Canada in ten years ending June, 1890.

Great Britain	37,637,431	1,480,816	13,688,367	362,131
United States	26,315,338	1,205,153	79,025,378	2,407,070
British West Indies	107,413,117	3,556,781	123,709,974	3,710,588
Spanish West Indies	138,539,939	4,704,570	345,456,673	10,711,733
Germany	6,356,377	184,906	183,986,495	5,199,498
Holland	1,426,300	30,467	.....	.....
British Guiana	4,810,146	172,131	38,550,662	1,319,071
Newfoundland	155,879	6,264	.....	.....
French West Indies	315,953	12,201	1,787,479	55,213
Belgium	1,392,272	56,160	2,835,870	64,996
Brazil	5,135,684	142,679	376,617,435	9,332,022
St. Pierre	2,179	166	.....	.....
Hawaiian Islands .....	.....	.....	.....	.....
Danish West Indies	24,937	869	.....	.....
France .....	.....	.....	.....	.....
Dutch West Indies .....	.....	.....	62,187	1,976
Dutch East Indies	12,654,906	428,773	34,816,215	856,242
China	4,921,635	211,917	28,022,466	704,393
Peru .....	.....	.....	.....	.....
Sandwich Islands	10,017	701	.....	.....
Spanish possessions in the Pacific	1,597,077	32,193	170,813,872	3,972,710
Central America	1,098,310	39,766	.....	.....
British East Indies	1,849,748	74,004	.....	.....
British Africa	829,217	23,294	19,576,725	472,606
Austria	153,038	10,772	.....	.....
Japan	1,377	68	.....	.....
Total	352,690,897	12,374,651	1,418,949,798	39,170,249

Statement of Sugar, raw and refined, imported into Canada in ten years, ending June, 1900.

Countries whence imported.	Refined.		Raw.	
	Quantity.	Value.	Quantity.	Value
	lbs.	\$	lbs.	\$
Great Britain	17,183,983	429,160	7,822,363	179,871
United States	55,972,206	1,724,532	213,481,515	5,149,077
British West Indies	3,691,089	100,970	144,876,056	3,497,378
British Guiana	493,788	14,850	57,987,988	1,587,767
Spanish West Indies	899,300	25,099	437,729,180	13,328,558
China	13,890,024	487,299	2,673,598	75,087
French West Indies	2,000	50		
Hong Kong	909,281	27,433	9,818	151
Dutch East Indies	169,809	5,070	204,849,309	4,620,161
France	1,897	69	25,443,867	533,570
St. Pierre	2,063	95		
British East Indies	3,989	126	7,188,857	126,310
Germany	14,838,985	392,973	827,552,307	19,620,819
Dutch West Indies	200	10	2,524	58
Austria	4,040,979	106,289	13,305,315	281,353
Holland	4,383,820	123,325		
Japan	738	20		
French possessions, all other	55,545	2,421	35,195,526	840,544
Belgium	5,157,109	112,435	247,566,106	5,376,693
Peru	35,711	911	21,174,260	457,806
Brazil			27,546,193	572,880
British Africa			891,856	18,976
Danish West Indies			1,270,742	26,916
Egypt			778,352	16,410
Turkey			13,191,107	340,586
Spanish East Indies			35,000,540	692,347
Hawaiian Islands			26,880	599
Spanish possessions, all other			430,290,207	8,825,503
Total	121,723,516	\$3,553,137	2,755,864,466	\$66,169,420

Statement showing the estimated population of Canada for each fiscal year from 1870 to 1891 as published by the Department of Agriculture.

Fiscal year.	Population.	Fiscal year.	Population.	Fiscal year.	Population.
1871	3,518,411	1881	4,336,504	1891	4,846,377
1872	3,610,992	1882	4,383,819	1892	4,899,273
1873	3,668,220	1883	4,433,363	1893	4,953,557
1874	3,825,305	1884	4,485,395	1894	5,009,296
1875	3,886,534	1885	4,538,790	1895	5,066,562
1876	3,949,163	1886	4,589,414	1896	5,125,436
1877	4,013,071	1887	4,638,109	1897	5,185,990
1878	4,078,924	1888	4,688,147	1898	5,248,315
1879	4,146,196	1889	4,739,617	1899	5,312,500
1880	4,215,389	1890	4,792,605	1900	5,378,800

Manitoba not included in estimated population until 1871.

British Columbia not included in estimated population until 1872.

Prince Edward Island not included in estimated population until 1874.

The Territories not included in estimated population until 1881.

The above statement of the importation of sugar and of the estimated population,

for which I am indebted to the Customs Department at Ottawa, show that during three consecutive periods of ten years each there have been imported into Canada of sugar, raw and refined, the following number of pounds :—

In the ten years ending	Lbs.	Valued at
1880	997,974,114	\$48,765,729
1890	1,771,640,695	51,544,900
1900	2,877,587,982	69,722,557

These figures show that the average yearly increase in importations in the ten years from 1890 to 1900 was 33,228,070 pounds, or 42.9 per cent. greater than that for the ten years from 1880 to 1890 ; but the average yearly increase in population is only 15.6 per cent. greater during the former than during the latter period. The proportional increase, therefore, is considerably greater in sugar than in population. Upon the basis that one factory has the contracts for 5,000 acres of sugar beets, yielding 15 tons of beets per acre, and that 100 lbs of beets yields 10 lbs of granulated sugar, it would require at least nineteen factories, running full time, to produce the sugar imported annually during the above ten year period ending 1900. Nineteen factories would, therefore, handle 1,425,000 tons of beets, which, at the average price of \$4 per ton, would represent \$5,700,000 distributed among and put into circulation through 142,500 farmers. Granting that labor constitutes about 60 per cent. of the total cost of cultivating and delivering at the factories, from the above required 1,425,000 tons of beets, there would be distributed annually for labor on the farm about \$1,995,000.

Not only is the beet sugar industry profitable to the farmer ; but properly managed as all large manufacturing industries in order to pay must be, it is also profitable to the sugar manufacturer, who employs extensively both skilled and unskilled labor.

In conclusion, I quote from Herbert Myrick's "Sugar: A New and Profitable Industry," under advantages of the industry :—"To agriculture, it affords a new crop that puts into the farmer's pocket money that would otherwise go out of his community and out of the country ; by thus reducing the area of other crops it helps all farm values ; the beet requires good farming, and is an educator in thrift and does not rob the soil.

"To labor, the beet sugar industry offers a new field for employers of both skilled and unskilled labor of all ages, and pays a satisfactory price for it in money that would otherwise go out of the community and out of the country.

"To capital, it pays a fair return, and under proper management should prove an absolutely safe investment.

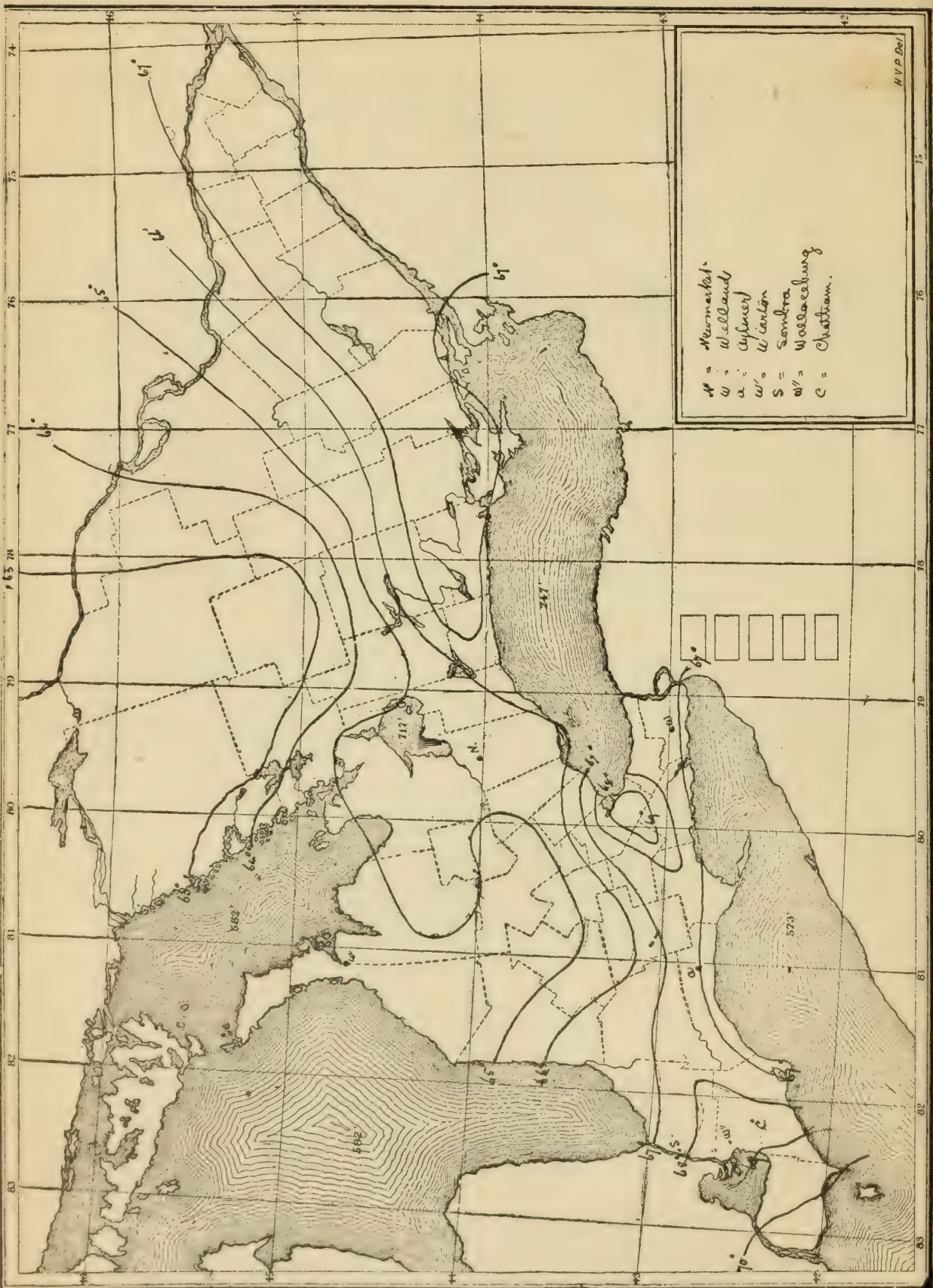
"To other industries, the beet sugar business contributes largely. The annual expenditure for labor and material, such as coal, lime, coke, bagging, chemicals, oils, etc., would amount to millions of dollars.

"To real estate, the beet sugar industry creates value."

MEAN SUMMER TEMPERATURE IN ONTARIO.

June—July—August.

Through the kindness of the Director of the Meteorological Office, Toronto, I have been furnished with a map showing the mean temperature curves for the past summer (June, July, and August) over the larger portion of Ontario. A mean of 70° for the above summer months is considered to be the most favorable temperature for the high development of the sugar beet. Other conditions, however, such as rainfall, length of seasons, etc., have to be considered. Our two experimental points, Aylmer and Welland, have a mean summer temperature of practically 67° ; Newmarket, between 66° and 65° ; while Wiarton, lying still more to the north, produces invariably, with proper cultivation, sugar beets of very high quality. The extent of the Province where sugar beets can be successfully grown for factory purposes can be determined only by actual trials.



Map showing mean summer temperature in Ontario (June-August, 1900.)

8114
ONTARIO AGRICULTURAL COLLEGE

BULLETIN 114.

DAIRY BULLETIN

BY THE

DAIRY SCHOOL, GUELPH.

ONTARIO DEPARTMENT OF AGRICULTURE,
TORONTO, ONT., MAY, 1901.

AGRICULTURAL COLLEGE AND EXPERIMENTAL FARM.

DAIRY BULLETIN.

INTRODUCTION.

By H. H. DEAN, B.S.A., PROFESSOR OF DAIRY HUSBANDRY.

THE DAIRY COW. The basis of successful private, or co-operative dairying is the dairy cow. The ideal cow does not belong to any special breed, but good cows are found in nearly all breeds, and among those having no special breeding. Good cows are more common among what are known as the dairy breeds. The most promising young cows in the dairy herd at the College are grades and pure-breds of the following breeds: Holstein, Ayrshire, and Jersey. The dams of the young grade cows were chiefly Short-Horn grades. As Short-Horn grade cows are the most common in Ontario, we would recommend dairymen to grade their herds with pure-bred males of one of the three breeds named. For cheese factory purposes and general dairying, use pure-bred Holstein and Ayrshire males; for butter-making as a specialty use pure-bred Jersey males. Rear the heifer calves from all cows giving 6,000 lbs. milk or over, or which produce 250 lbs. of butter in a year, and in a few years the herd will be a credit to the owner.

Feed the heifer calves new milk for two weeks to one month; then gradually change to sweet, warm skim-milk, to which has been added for a time a small quantity of bran and ground oats. Afterwards, feed the meal dry and give clover hay and a few roots. Keep the calves clean, warm, and dry. Do not turn the calves out of doors, except for exercise during the first summer. Breed these heifers to drop their first calves when from two to three years old. Milk them for ten to twelve months during the first milking period, and breed the second time in from three to six months after dropping the first calf. At the end of the second milking period, sell all heifers which do not reach the standard of 6,000 lbs. milk or 250 lbs. butter in a year.

FEED OF THE DAIRY COW. In spring and early summer, when pasture is good, nothing further is required, except salt and plenty of pure water. When pasture becomes short, feed green peas and oats, bran and corn silage. A small summer silo is a necessity on the dairy farm. In winter, feed corn silage mixed with cut clover hay and straw or chaff and pulped mangels as the basis of the ration. To this add six to eight pounds of meal for each pound of fat in the milk or for each 25 or 35 pounds of milk which the cow gives. The meal may be mixed in the proportion of one-half bran and the remainder equal parts of ground peas and oats. Give the cow all the roughage, such as silage, hay, and she will eat; but feed the concentrates, or meal, according to her milk flow, as straw, which these are expensive.

If possible, water in the stable during winter. A heavy galvanized iron water trough placed above the manger, may be put in to a stable for thirty cows, at a cost of about \$20, where a water tank is already in the barn. The trough should be six to eight inches wide on the top, four to six inches wide in the bottom, and about four inches deep. It should slope to one end, having an outlet for ease in cleaning.

VENTILATION AND LIGHT IN STABLE. Each cow in the stable should have 600 to 800 cubic feet of air-space. The foul air should be removed from both the ceiling and the floor of the stable. The fresh air should enter through a sub-earth duct, which may be made of two rows of ten inch tile placed six to ten feet in the ground and carried a distance of at least 100 feet from the barn. Where drainage is good, ordinary field tile may be used; otherwise, sewer tile with joints cemented should be placed in the trench. The intake pipe should be thirty to fifty feet high, having a cowl on the top, constructed so that the opening will always face the wind. The air from the duct should be distributed along the ceiling of the stable and in such a way as not to cause a draft on the cows.

Dairy stables should have plenty of light, and the windows should be kept clean and bright, to admit the rays of the sun and promote health among the stock.

FACTORY FLOORS. Substitute, as soon as possible, a cement floor for the wooden floor now in your factory or creamery. Grade the ground to a slant of one inch in six feet to a central gutter, then pack the earth firmly and cover with four to six inches of gravel. Pound the gravel solidly. Mix sand and gravel with good cement in the proportion of four or five to one, and lay the grouting about four inches thick on the firm gravel. Finish with one inch of screened sharp sand and the very best brand of cement mixed in the proportion of one to two for the finishing coat. Have the surface smooth so that pools of water will not lie on the floor. The gutter should have a fall of one inch in six to eight feet, to an outlet, and should be made specially solid and even on the sides and bottom. Employ a skilled workman to lay the floor, and use none but the very best material.

Place a "bell-trap" at the outlet from the gutter. Use sewer tile with cemented joints in underground drains near the factory, to prevent sewage from soaking into the well. The sewage may be disposed of by means of a filter-bed or by the sub-earth system. Do not allow it to accumulate about the factory.

PAYING PATRONS. Milk is valuable for butter-making in proportion to the fat which it contains, and the pounds of fat delivered in the milk or cream should form the basis of dividing proceeds among patrons of the creameries.

As butter consists of fat, together with about 16 per cent. of water, salt, and curdy matter, there will always be more butter than the fat contained in the milk. This excess of butter over fat constitutes what is known as the "overrun." The "overrun" varies from twelve to sixteen per cent., *i.e.*, 100 lbs. fat in the milk makes from 112 to 116 pounds of butter, and this "overrun" belongs to the patrons, unless otherwise understood. It is unwise for creamery managers to take the "overrun" as part payment for manufacturing.

For calculating the yield of butter from fat in the milk, adding one-sixth to the fat is near enough for practical purposes.

Cheese is made largely from two constituents in the milk, *viz.*, fat and casein; therefore, the method of dividing proceeds among the patrons of cheese factories is more complicated than for creameries. Three systems are now in use among factorymen:

1. Paying according to the weight of milk delivered regardless of its quality.

The principle of this plan is that all milk is of equal value per 100 pounds for cheese-making. It rests on a false assumption, is unjust, and it tends to promote dishonesty. Factorymen and honest patrons who complain that some of the milk is skimmed and watered by dishonest patrons, deserve little sympathy, because a remedy is within the reach of all at a very small cost. The milk of all patrons should be tested regularly, and be paid for according to its value for cheesemaking.

2. Paying according to the weight of fat delivered in the milk, the same as at creameries.

The principle of this system is that all milk is valuable for cheese-making in proportion to the fat which it contains. The system is manifestly more just and equitable than the first named, and is to be commended in preference to "pooling" by weight of milk. The chief weakness of the plan is that the yield of cheese is not in direct proportion to the fat contained in the milk; therefore, it gives an undue advantage to the patrons sending milk containing a high percentage of fat.

3. Paying according to the fat and casein in the milk, the casein being represented by the factor 2, added to the percentage of fat.

The principle of this system is that milk is valuable for cheese-making in proportion to the fat and casein contained in it, and it further assumes that the percentage of fat + 2 represents the available fat and curdy compounds in milk for cheese-making.

The application of the third system is very simple. To illustrate: The tests for fat of patrons' milk are 3.0, 3.5, 3.8 and 4.0. The percentage of fat and casein are $3 + 2 = 5.0$; $3.5 + 2 = 5.5$; $3.8 + 2 = 5.8$; and $4 + 2 = 6.0$. The pounds of fat and casein are calculated by multiplying the pounds of milk delivered by the percentage of fat and casein. Thus, if the first patron had 1500 lbs. milk, he would be credited with $1500 \times 5 \div 100 = 75$ pounds of fat and casein. If the second delivered 2000 pounds milk he would be credited with $2000 \times 5.5 \div 100$, or 110 lbs. fat and casein, and so on with all the others. The value of one pound of fat and casein is ascertained by dividing the net proceeds of the sale of cheese by the total pounds of fat and casein delivered.

The following table gives a summary of the results obtained during five years experiments, in which 250 experiments were made with nearly 200,000 lbs. of milk, which contained percentages of fat varying from 2.7 to 5.5.

Av. p.c. fat in milk.	Lbs. cheese made per 100 lbs. milk.	Lbs. cheese made per 1 lb. fat in milk.	Lbs. cheese made per lb. fat and casein or p.c. fat + 2.	Lbs. loss of fat and casein in whey.		Per cent. lost in curing in four weeks.	Average score.	
				Per 1,000 lbs. milk.	Per 100lbs. cured cheese.		Flavor max. 35.	Total max. 100.
2.87	8.75	3.04	1.79	2.71	3.09	4.26	30.4	89.9
3.22	9.03	2.80	1.72	2.75	3.15	4.43	30.2	89.4
3.83	10.02	2.61	1.71	3.34	3.21	4.10	30.8	90.3
4.23	10.67	2.53	1.71	3.21	3.02	4.05	31.0	90.4
4.74	11.44	2.41	1.69	3.64*	3.18*	3.07	31.0	89.8
5.21	12.13	2.32	1.68	3.40*	2.80*	3.53	31.5	91.6

* Fat only. Casein not determined.

Amounts of money (cheese 8c. per lb.) credited by three systems and also value of cheese.

Average p.c. fat in milk.	Weight of milk— 1,000 lbs. milk.	Weight fat in 1,000 lbs. milk.	Weight of fat and casein in 1,000 lbs. milk, or fat plus 2.	Value cheese made from 1,000 lbs. milk.
	\$ c.	\$ c.	\$ c.	\$ c.
2.87	8 27	5 91	6 69	7 00
3.22	8 27	6 63	7 18	7 22
3.83	8 27	7 89	8 02	8 02
4.23	8 27	8 71	8 56	8 54
4.74	8 27	9 76	9 27	9 15
5.21	8 27	10 73	9 91	9 70

"Our five years' experiments prove that this third system comes nearest to the actual value of the cheese produced, though it still places a slight premium on the milk-fat. It encourages the production of good milk, and at the same time does not discourage the majority of patrons who have average milk, and who are apt to envy those whose cows give a small amount of rich milk, and who draw a large share of the proceeds of cheese-sales, when the money is divided on the basis of the fat only."—O. A. C Report, 1898, p. 52.

SKIM-MILK, BUTTER-MILK AND WHEY. The value of skim-milk for young calves and pigs is much increased by feeding it sweet. The separator creamery should heat all skim-milk to 185°, and in hot weather cool it to 60° or below before it leaves the creamery, if at all possible. Sweet skim-milk is probably worth 15 to 20 cents per 100 lbs. It has also about the same value for grown pigs when sour, if fed along with meal.

Butter-milk has about the same value as sour skim-milk, if it does not contain too much water. When selling butter-milk in bulk at the creamery, a convenient way is to value it at so much per ton of butter. From two to three dollars per ton of butter is a fair price.

Experiments made at the Ontario Agricultural College showed that 100 lbs. of whey were equal to 14 lbs. of meal in the production of bacon. Both skim-milk and whey had a marked influence in the production of *firm* bacon. When selling whey in bulk at the factory, it is usually valued at from three to six dollars per ton of cheese.

The by-products of cheese-making and butter-making are valuable factors in adding to the wealth of dairymen through bacon hogs, and the rearing of young cattle for beef and the dairy.

HINTS ON THE CARE OF MILK FOR CREAMERIES AND CHEESE FACTORIES.

BY R. W. STRATTON, ASSISTANT INSTRUCTOR IN CHEESEMAKING.

Milk is the raw material from which the butter or cheese maker produces a finished product. It is a perishable article, and it is easily injured; hence it is very important that great care be taken to keep it sweet and free from any undesirable germs or taints.

The care of milk should begin before milking, by seeing that the cow or cows are clean, the stables clean and well ventilated, the surroundings neat and tidy. It is also very important that there be no dust or bad odors in the stable at the time of milking, as the thin stream of milk passing from the teat to the pail will collect a large amount of any impurities that may be in the atmosphere.

Before commencing to milk, the udder and flanks of the cow should be brushed or wiped with a damp cloth to remove loose hairs, or fine particles of dust or filth. The milker should be clean, kind, and sympathetic. He or she should milk with dry hands, milk exhaustively, and as quickly as possible.

Immediately after milking, remove the milk to a clean, pure atmosphere, and strain it through a fine wire strainer, having at least four ply of cheese cloth underneath, to remove fine particles of dirt; as no matter how carefully the milking is done, there is likely to be some dirt in the milk, and this dirt or dust should be removed as quickly as possible.

Special provision should be made to have a good, clean, covered stand with latticed sides, and a free circulation of air from all directions. This milk-stand should be convenient to an abundant supply of pure water, and have surroundings free from any bad odors. There should also be a water tank, large enough to hold at least the milk from two milkings. A crane for lifting cans of milk in and out of the water tank is very convenient, and saves labor. A wire handled dipper should be provided for stirring the milk. The milk should be aired and cooled to about 65° to 70° for cheesemaking, and to 60° or below for buttermaking. If sent to the factory, Saturday night's and Sunday morning's milk should be cooled to at least 54°, and be held at that temperature. No reasonable amount of stirring will keep the cream from becoming tough and leathery, unless the milk is cooled more quickly than the atmosphere will cool it. This tough cream will not mix with the milk again in such a way that it can be incorporated in the cheese, and the presence of such cream will cause an excessive and unavoidable loss of fat in the process of cheesemaking.

For patrons having a small amount of milk, a very convenient and inexpensive method is to fasten hooks to a pole under a roof, and hang the pails of milk on the hooks. The milk may be poured from one pail to another to aerate; and being in small quantities, the milk cools rapidly to the temperature of the atmosphere. Of course, the pails should be washed after milking, and the milk strained, even when left in pails over night. The night's and morning's milk should be delivered in separate cans, or be kept separate as long as possible.

When purchasing tinware, examine the seams carefully and see that all joints are well soldered, so as to leave no lodging place for filth, which is a very common source of trouble. Another point of importance is to have the bottoms of pails, cans, etc., with concave bottoms, not convex, as in the former case the milk drains into the center of the can; while in the latter, some of it is left in a channel around the edge and cannot be easily removed by the brush.

Wash and cleanse thoroughly, each time of using, all utensils used in handling milk. First, rinse them with warm water; then, wash well with water at a temperature of about 110° to 120° ; and, then, scald or steam. Do not wipe them with a cloth, but place them where they will get plenty of sunlight and pure air. Use a brush in preference to a cloth for washing utensils. A free use of washing soda, or sal soda, will be found beneficial; but soap should never be used on milk cans or pails. The occasional scouring with salt will serve a good purpose. Wooden pails should never be used for milking.

Some of the most common defects in milk delivered at factories are: *lack of proper straining*, or no straining at all—an unpardonable sin; *bad flavors*,—caused by poor or decayed food, by cows drinking dirty water, by carrying milk in rusty cans or milking into rusty pails, by lack of cleanliness in milking and care of utensils, especially in the case of cans in which whey has been returned, by milk standing in an impure atmosphere, by unhealthy animals, and by cows eating weeds; *over-ripeness*,—caused by lack of cooling on the farm, or delay in hauling to the factory; *dust*, from roads in hot, dry weather; injurious results from *exposure* to hot sun on milk-stands and wagons; *injury from freezing* in winter.

Under no circumstances should chemicals be used to preserve milk. If proper provision be made for controlling temperatures, the milk producer will be independent of thunder storms, hot, close, or muggy weather, luck, etc.; and the occasions for returning milk will not be so common as at present.

A CURD TEST.

Provide glass jars holding about a pint. The ordinary composite test bottle is suitable, though a jar with straight sides is better, as the curd may be cut better and more easily in such a jar. Thoroughly clean and sterilize them. Also have each bottle plainly numbered and have a cover for each bottle.

Provide one bottle for each lot of milk to be tested. Fill each bottle about two-thirds full of the suspected samples of milk and place them in a water bath, having the water in the bath about the same depth as the milk in the bottle. Heat the water to 98° , and when the milk has reached a temperature of 98° , add 10 drops of rennet extract to each sample, and mix by giving the bottle a rotary motion. After the milk has coagulated so as to be quite firm, cut it fine with a knife having a solid metal handle, care being taken to sterilize the knife after cutting the curd of each sample, so as not to contaminate one lot with flavors from another lot or sample.

As soon as there is a good separation of whey from the curd, pour off the whey, keep the water surrounding the samples at a temperature of 98° , and pour off the whey from time to time. If there has been any bad flavor, or gas present in the sample of milk, the temperature at which the test is made is favorable for the development of the same. Keep the samples of curd from six to ten hours, and then examine carefully the flavor and texture of each, by smelling and cutting with a sharp knife.

The test is particularly valuable in detecting flavors which develop in the curd but cannot be detected in the ordinary way at the time of delivery. The test is also valuable for convincing patrons who may doubt about the quality of their milk being so bad as it is represented by the cheese-maker, as it is possible to have them see and smell the curd made from each patron's milk as delivered at the factory.

THE PREPARATION AND USE OF A CULTURE, OR STARTER.

That there has been such a strong prejudice against the use of cultures or starters in the minds of some of our best buyers, is not to be wondered at when we consider the careless, slipshod methods in which some makers prepare cultures, and the unrestricted use of them by others, regardless of the acidity of the milk or the flavor of the culture. The flavor of the culture used will largely determine the flavor of the cheese or butter made. Therefore the need of full and exact knowledge of the proper method of preparing and using cultures is manifest.

First, provide suitable cans. It is better to have a duplicate set, if possible. Cans similar to the ordinary shot-gun cans, which are 8 inches in diameter and 20 inches deep, are quite suitable. When the milk is in small lots it can be more readily heated and cooled than if it is kept in larger quantities.

If large quantities of culture are needed, a special box or tank, large enough to hold the cans containing the culture for one day's use, should be provided. This should have steam and cold water connections. The cans may be left in this box, so as not to be influenced by the outside temperature.

The O. A. C. Bacteriological Department is now prepared to send good cultures to anyone applying for them, for the sum of twenty-five cents, which scarcely covers the cost of preparing and mailing. In starting a culture, we think it advisable to obtain a commercial culture. Empty the mother culture into a quart of cooled, pasteurized milk. Allow it to stand at a temperature of 80° for three or four hours, then add it to about ten pounds of pasteurized milk. This culture should be ready to propagate next day.

After selecting the milk, add about 20 per cent. of pure cold water and heat to 185°, stirring constantly while it is being heated. Allow the heated milk to stand for twenty or thirty minutes at this temperature; then cool it rapidly to 75° or 80°, and add from two to four per cent. of the old culture; stir well, cover the cans with a piece of close fitting glass, and set away in a moderately warm, pure atmosphere. Do not disturb it until it is required for use.

Before using, remove from one to two inches of the milk from the surface of the can, as the flavor of the surface is not so good as that which is below. Then break up the remainder by stirring it well in the can; take out what is required and pour it a few times from one pail to another until it has a creamy consistency, in which condition it will be ready for use.

The indications of a good culture are as follows: the whole mass is firmly coagulated, no water is found on the top, and it has a mild acid flavor, pleasant to both taste and smell.

A culture may be used to advantage when the milk is maturing slowly, and when it is tainted or gassy. One per cent is the greatest quantity which should be used at any time, and this quantity should be used only after the acidity of the milk has been ascertained by the rennet test and it is found necessary.

Do not ripen the milk so low by two or three seconds when using a culture. Bear in mind that a culture may be used to advantage only when it has a good flavor, and when the milk is in such a condition that its use is a necessity. With gassy milk its use is especially beneficial. The practice of using a culture when not needed, or of using one which is poor in flavor, should be avoided.

A wire-handled dipper is preferable for stirring the milk in the preparation of a culture.

With the exception of a few special butter cultures, a culture that is good for cheesemaking is equally good for cream ripening, and *vice versa*.

By thoroughly sterilizing cans, dippers, and everything brought in contact with the culture, a good culture can be propagated for an indefinite length of time by adopting the pasteurizing method as explained in the foregoing.

CHEESE MAKING.

BY GEO. H. BARR, INSTRUCTOR.

It has been said that the average man is naturally dirty, and disorderly, and cheese-makers are not better in this respect than the average man. It is certainly true that the general opinion of the public is that a cheese factory is a dirty, bad-smelling place.

This is something that should be removed from the public mind, and can be done only by factory owners and cheese-makers putting forth united effort in repairing, cleaning, painting, and white-washing the buildings, and being themselves clean and tidy. Let every factory owner and cheese-maker make a strong effort to put our cheese factories into better sanitary condition, and keep them so. Cement floors and a proper system of sewage disposal, as recommended by Dr. Bryce, of Toronto, are two features that will help greatly to improve the sanitary conditions of the cheese factories. The training which our young men receive at the Dairy Schools, should have a marked tendency to improve the appearance of the cheese-maker, and the inside of the factory.

The time has come when the old curing-room, with cracks in the floor, ceiling, and walls, loose windows, and badly fitting doors, and in which the temperature is regulated by the temperature of the atmosphere outside, should be a thing of the past; and in its place should be a room thoroughly insulated, in which, by means of a sub-earth air duct, compressed air or ice, the temperature can be kept below 65 degrees in the hottest summer weather. This is absolutely necessary to produce the finest cheese in summer.

To build new curing-rooms of this description would mean a great deal of expense to factory owners; but we do not consider it necessary to erect new buildings, in order to secure proper insulation.

The present curing-rooms can be made almost as good as new ones, by the judicious expenditure of say, two hundred or two hundred and fifty dollars each. This amount would cover the cost of a sub-earth air duct, and of lining the room inside in the following manner: For the ceiling and walls, first, put on two thickness of building paper; on this nail 2 x 2 inch strips, two feet apart; then two thickness of paper again, and cover with inch lumber dressed on one side. On the floor, put two thickness of building paper, and cover with 1½ inch dressed flooring. Put in double windows with glass frosted, and double doors. This, if properly done, would put hundreds of dollars into the pockets of the patrons of cheese factories, by putting on the market cheese cured at the proper temperature.

HEATING CURING-ROOMS. A coal furnace with an asbestos jacket, placed in or near the centre of the room, is the best means of heating. A furnace of this kind causes a good circulation of the air in the room; and, if it is carefully attended to, the temperature need not vary more than two or three degrees, night or day, provided the curing-room is properly built.

MILK FOR CHEESEMAKING. In the manufacture of cheese, the first and most important matter, is to have the milk delivered at the factory, clean, sweet, and of good flavor. This question has been a source of much thought and discussion amongst dairymen. For years the old story has been preached—"be cleanly, be cleanly, aerate, aerate;" and still we receive bad flavored milk, and still have bad-flavored cheese.

We would suggest that our Instructors spend more time among the patrons than they have done in the past, and, with the assistance of our chemists and bacteriologists, find out the causes and remedies for so much bad-flavored milk and cheese.

RENNET TEST To make a rennet test, take eight ounces of milk at 86 degrees Fahr., place a piece of stick, about half an inch long, in it for an indicator; add one drachm of rennet extract; stir rapidly for ten seconds; and note the time from adding the extract till the time the indicator stops and turns back a little. No definite number of seconds can be laid down as a rule to go by, but usually from 18 to 22 seconds will give good results. The proper rule is to set at the number of seconds that will leave $2\frac{3}{4}$ or 3 hours from the time of setting the vat till the time of dipping the curd, with the proper amount of acid on the hot iron.

SPRING CHEESE. Spring cheese means cheese that will be ready to ship in ten days or two weeks after making. To make this class of cheese it is necessary to use a large quantity of rennet and a small amount of salt. Heat the milk to 86 degrees, stirring slowly while heating. If making colored cheese, add color as soon as the weight of milk in the vat is obtained, using one to one-and-a-half ounces of color to 1,000 pounds of milk, and stirring till the milk is all uniform in color. Make a rennet test, and set so that the curd will remain in the whey $2\frac{3}{4}$ hrs. to 3 hrs. from setting to dipping, using 4 to 5 ounces of extract per 1,000 pounds milk, or enough to coagulate the milk fit to cut in 17 to 20 minutes. Commence to cut early, using the horizontal knife first, cutting slowly lengthwise of the vat; then, with the perpendicular knife, cut crosswise, and afterwards lengthwise, which will be sufficient for normal milk. Stir the curd carefully with your hands or with agitators for 10 or 15 minutes before turning on steam, being careful to have the curd all free from the bottom and sides of the vat before applying steam. Rough handling while cooking will cause loss of butter fat, check development of acid, and make a rough feeling curd.

Heat to 98 degrees in $1\frac{1}{2}$ hrs from the time of setting. If using agitators, take them out as soon as the curd shows the slightest sign of acid on the hot iron, run off part of the whey, and stir by hand, or with a rake. Acid usually develops very quickly in the spring; therefore it is necessary to have one-half or more of the whey drawn off before the curd shows enough acid to dip.

Dip when the curd is nice and firm and shows 1-16 inch of acid on the hot iron.

Be careful not to leave too much moisture in the curd at the time of dipping in spring.

It is a mistake to leave the curd very moist, and expect a fancy spring cheese.

Leave the curd about eight inches deep in the curd sink; when it is well matted together, cut into strips about six inches wide and turn upside down; and in about fifteen minutes turn again and pile two deep. Continue turning often enough to keep the whey from gathering on the curd, until the curd shows $\frac{3}{4}$ inch acid, when it should be milled, and well stirred afterwards every 15 or 20 minutes, until it shows, when squeezed in the hand, a nice mixture of whey

and butter, feels mellow or velvety, and has a flavor like newly made butter. Stir the curd well before adding salt, to give the cheese good body, a good flavor, and silky feeling. Salt at the rate of $1\frac{1}{2}$ to 2 pounds of salt per 1,000 pounds milk. It is important that the temperature of the curd from dipping to milling be about 94 degrees. After milling, allow the curd to cool gradually to about 85°, when ready to salt, and put to press at a temperature of 82 to 84 degrees.

Weigh the curd into the hoops. Tighten the press slowly, and leave the cheese 45 minutes before taking out to bandage or dress.

When bandaging, use plenty of clean, warm water and what is commonly called "skirts" These are strips of thin cotton which are wide enough to lap over each end of the cheese about one inch, and long enough to go around the cheese. These cloths help to make a good rind on the cheese, and keep them clean, until they are put on the shelves in the curing-room. The skirts are then taken off and washed along with the press cloths, when they are ready for use again.

Turn all cheese in the hoops every morning, and put no cheese in the curing-room which is crooked, has wrinkles in the bandage, shoulders, or rough edges.

SUMMER CHEESE. Great care should be exercised in selecting the milk at the weigh-stand during the summer months, rejecting, as far as possible, all over ripe, gassy, or tainted milk.

One ounce of color is usually enough for summer cheese, and three ounces of extract per 1,000 pounds milk, or enough to coagulate the milk fit to cut in 25 to 30 minutes. Cutting and cooking curd, the same as in the notes on spring cheese.

The amount of acid at dipping should be $\frac{1}{8}$ to $\frac{1}{4}$ inch. The method of handling the curd from the time of dipping to the time of milling, is the same as in the notes on spring cheese. Mill with $\frac{3}{4}$ to 1 inch of acid on hot iron; and immediately after milling, wash the curd with clean, pure water, at a temperature of 98 degrees, using about the same weight of water as of curd.

Washing curds has become quite general during the past two years, and no doubt will improve the general run of curds during the summer months; but care must be taken not to salt the curd too soon, or open cheese may be the result. The curd after washing has a much smoother feeling, which may be mistaken for the mellow feeling desired at time of salting.

Be very careful not to salt summer curds too soon. Fifteen or twenty minutes extra stirring and airing may make the difference between having a *fair* cheese and a *fancy* one. The same amount of salt may be used on washed as on unwashed curds, and should be from $2\frac{1}{2}$ to $2\frac{3}{4}$ pounds per 1,000 pounds of milk. Curds need not be covered after milling in summer, and should have all the fresh air possible for half an hour before salting.

FALL CHEESE. In making fall cheese, it will usually be found necessary to use a culture, to hasten the ripening of the milk. Use a culture prepared as recommended in this bulletin.

If making colored cheese after the cows are in the stable, it may be necessary to use a little more color. Use the same amount of extract as for summer cheese, or enough to coagulate the milk fit to cut in thirty minutes.

Try to get along with $\frac{1}{4}$ inch of acid at dipping, and keep the curd at a temperature of about 94 degrees until milling. Mill when the curd is flaky and shows from 1 to $1\frac{1}{4}$ inches acid. Salt at the rate of $2\frac{3}{4}$ to 3 pounds per 1,000 lbs. milk. Use plenty of hot water when bandaging, and also around the hoops after putting to press again. It is a question if washing curds late in the fall,

will improve the cheese. My own experience is that it does not, but others may have found it to do so.

GASSY MILK. Gassy milk does not ripen so quickly as good milk ; so, if it can be had, it is advisable to use a culture which will help to overcome the gas. Allow gassy milk to ripen 2 or 3 seconds lower, by the rennet test, than normal milk before setting. In cutting, aim to have the cubes as large as possible, in order to retain more moisture, and hasten the development of acid.

Stir for 20 or 25 minutes before turning on any steam, and take about 2 hours from setting to having the curd cooked to 96 degrees.

As soon as acid begins to develop nicely, raise the temperature to 98 degrees, and dip with the same amount of acid as normal curd, leaving a little extra moisture in the curd in the sink.

Cut and turn as usual, piling 3 or 4 deep, until the gas holes flatten, when it should be milled and washed with its weight of water at a temperature of 100 to 102 degrees ; then with the same amount of water at 98 degrees, stirring and airing well. About half way between milling and salting, commence piling the curd as high as possible, leaving it for about 20 minutes ; then spread it out, stir well, and pile again, continuing to do this until the curd is as nice and mellow, as a good curd should be. Give plenty of fresh air before salting, and put to press at a temperature of 80 degrees if possible.

TAINTED MILK. Tainted milk, if not over-ripe, can be improved by using a good clean-flavored culture, after which it should be handled in every way the same as normal milk, giving the curd all the fresh air possible, and plenty of time to allow the taint to pass off before salting.

OVER-RIPE MILK. Over-ripe milk, if not very carefully handled, will make those dry, hard, short-textured cheese we hear so much about. We would advise not applying any heat to the milk until there is enough milk in sight to fill the vat, and then heat as quickly as possible to 82 or 83 degrees ; and after making a rennet test, set at these temperatures, using about one ounce extra of rennet per 1,000 pounds milk, stirring about two minutes. Commence cutting early and cut fine, using the horizontal knife for the extra cutting, cutting lengthwise of the vat. Where possible, use a finer knife ($\frac{3}{8}$ inch). Cook quickly to 98 degrees, and run off the whey as soon as possible. After all the whey is off, and just before dipping the curd into the sink, stir rapidly by hand in the vat for five minutes. This will firm up the curd more than ten minutes stirring in the sink.

If possible, give less acid at dipping than usual. Turn rapidly and loosely in the sink, avoiding smashing. Leave curd spread thinly on slats, and after cutting into strips, turn often and leave single. Mill early, or before it shows as much acid as a normal curd. Washing and handling after milling, the same as in the notes on summer cheese. Allow a curd of this description to mature well before salting.

CURING CHEESE A cheese is only half made when it is put into the curing-room ; therefore it is important that the curing-room should be well looked after, and everything done to maintain an even temperature at the best temperatures for each season, which are as follows : For spring, 65° to 70° ; for summer, 60° to 65° ; and for fall, 62° Fahr.

Cheese, when put into the curing-room, should be put on the top shelves all over the room, and then be dropped down to make room for the newly-made cheese. This method keeps the oldest cheese nearest the floor which is the coolest place.

Place the cheese straight and evenly on the shelves, and turn them every morning, excepting Sunday. Keep the curing-room well swept and looking neat and tidy.

By the liberal use of formalin in the curing-room, mould can be almost entirely prevented from growing on the cheese. It is best applied by the use of a small hand spray pump. It is important that there be the proper amount of moisture in the air in the curing room in order to prevent the growth of mould, and also to prevent the rind of the cheese from cracking. From 70 to 75 per cent. moisture, with a good circulation of air will give good results. Use good strong cheese boxes and have them fit the cheese. Put two scale boards on each end, stencil the weights plainly on the boxes, load them on nothing but clean waggons, and have canvas covers to put over the cheese when being teamed to the station.

MILK-TESTING.

By J. A. McFEETERS, INSTRUCTOR.

The ability to determine the composition of milk and its products to such an extent as will serve practical purposes, is a very desirable acquirement for the dairyman. The motives of the dairyman for wishing to know something about the quality of milk are threefold, viz., the improvement of his herd or manufactured product, the fixing of the commercial value of a purchased supply, and the detection of adulterations.

The two instruments most commonly used in the testing of milk are the Babcock tester and the lactometer. The fat content is accurately and speedily determined by the Babcock test, and the use of the Quevenne lactometer enables the operator to compare the density of milk with that of pure water. By the use of certain formulas he can also calculate quite closely the solids not fat in a sample of milk by the aid of these two tests.

THE BABCOCK TEST.

1. Be sure to obtain a representative sample. The whole benefit of any test is thrown away if the sample is not representative. Mix by pouring from one vessel to another.

2. By means of a 17.6 cubic centimeter (c.c.) pipette, take 18 grams of milk at a temperature of from 60 to 70 degrees.

3. Add to this 17.5 c.c. of commercial sulphuric acid with a specific gravity (sp. gr.) of 1.82 to 1.83, and thoroughly mix the acid and the milk by giving the bottles a gentle rotary motion.

4. Place the bottles in the tester and turn for from four to five minutes, at a speed varying from 700 to 1,200 revolutions per minute, according to the diameter of the machine (700 revolutions per minute with a machine twenty inches in diameter).

5. Add hot water at a temperature not lower than 140 degrees F. to float the fat into the neck of the bottle.

6. Turn the machine again for about two minutes and take the reading before the fat cools. If troubled with burnt readings, add the water twice instead of all at once, filling the bottle just to the neck the first time, then turn the machine about a minute, fill to about the eight per cent. mark the second time, and turn for another minute.

NOTES.

1. Always make sure that the pipettes and test bottles are clean before using.
2. Be very careful to measure the exact amount of milk for a test. A 17.6 c.c. pipette will deliver about 17.5 c.c. of milk. This measurement of milk of average quality will weigh 18 grams.
3. A partially churned sample of milk may be prepared for sampling by heating it to about 110 degrees F. and pouring it from one vessel to another to mix it thoroughly. When it is thus prepared, take a sample as quickly as possible.
4. In sampling frozen milk, it is necessary that both the liquid and the frozen part be warmed and mixed thoroughly. The unfrozen part is richer in fat and solids than the frozen.
5. A sample of milk that has soured and thickened may be prepared for sampling by adding a small amount of some alkali to neutralize the lactic acid, and cause the curd to redissolve. A small amount of powdered concentrated lye is very suitable. Add just a small amount of lye at a time, and pour the milk from one vessel to another, to mix the lye with the milk, which causes the casein to become dissolved.
6. The amount of acid used must be varied to suit its strength. The right amount is being used when the fat presents a bright golden appearance. Acid that is much too strong or too weak should be discarded, as satisfactory results cannot be obtained from its use. Acid a little weak is to be preferred to very strong acid. Carboys or bottles containing acid should be kept well corked, to prevent the contents from becoming weakened by absorbing moisture from the atmosphere.
7. Hold the test bottle at a slant when pouring in the milk. This will cause the milk to flow down the side of the neck, thus allowing the air to escape without causing the milk to splash.
8. Avoid pouring the acid directly on the milk. The test-bottle should be held at an angle so as to cause the acid to follow the side of the bottle and go directly underneath the milk. After the addition of the acid to the test bottle, the milk and acid should be in two distinct layers without any charred matter between them.
9. After the addition of the acid to the milk in the test bottle, the contents should not be allowed to stand long before they are thoroughly united by a gentle rotary motion.
10. If the temperature of the room be low, it will be necessary to pour hot water into the tester to keep up the temperature.
11. The water added to the test bottles should be soft or distilled. If hard water is used add a little sulphuric acid (half an acid measure, or a little more to a gallon of water) to soften it; this will prevent foam above the fat.
12. If the room is cold, or if there are several readings to take, *always* set the samples in hot water (140-150° F.) extending to *the top of the fat* before reading.
13. It is well to use a pair of dividers or compasses for measuring the column of fat. The points of the dividers should be placed at the *upper* and *lower* limits of the fat column; then if one point be placed at the zero mark of the scale, the division at which the other point touches will show the percentage of fat in the sample tested.

14. Burnt or cloudy readings may be caused by :

- (1) The use of too much or too strong acid.
- (2) Allowing the acid to fall directly on the milk.
- (3) Having the milk or acid at too high a temperature—the higher the temperature, the less acid is required.
- (4) Allowing a sample to stand too long after adding the acid, before mixing the milk and acid.

15. Light colored readings and floating particles of curd are usually due to :

- (1) The use of too little or too weak acid.
- (2) Having the milk or acid at too low a temperature—the lower the temperature of either, the more acid is required.
- (3) Insufficient shakings of the bottles to unite the milk and acid thoroughly.

16. After using the test bottles, rinse them at least twice with *hot* water. Rinsing with sulphuric acid before rinsing with water, or the use of a little sal soda in the first water, is often necessary. Discolored bottles may be cleaned by putting a small amount of common shot into the water used for rinsing. Simply rinsing the shot around the bottle will scour and clean it thoroughly.

17. If the scale on the test bottle becomes indistinct, it can be much improved by rubbing over it some black, viscous paint and wiping the neck with a cloth.

18. A convenient method of testing the accuracy of the graduation is to test the same milk in the different test bottles and compare the readings. A bottle that differs by more than $.2 \left(\frac{2}{10}\right)$ in its reading from the rest should be discarded. As the capacity of that part of the neck over which the scale extends should be 2 c. c., the accuracy of the scale may be tested by filling the bottle to the bottom of the scale with water at the temperature of the room, and then adding 2 c. c. of water at the same temperature by means of a 2 c. c. pipette or a finely graduated burette.

19. *Care* and *exactness* in every detail are absolutely essential requisites for reliable results in milk testing. There is more to learn in *care* than in principle. Carelessness on the part of the operator has frequently thrown suspicion on the Babcock test.

SKIM-MILK, BUTTER-MILK AND WHEY.

As the percentage of fat in skim-milk, butter-milk and whey is so small, the best method of testing these is by the use of the double-necked skimmilk bottle. The usual amount of milk or whey is taken and the test is made in the usual way. Very fine readings can be taken, as a very small amount of fat will extend over quite a length in the small neck. Considerable controversy has taken place from time to time among leading authorities as to how each division on the scale should be read, and it has been demonstrated that reading the first division as $.1 \left(\frac{1}{10}\right)$ and each succeeding division as $.05 \left(\frac{1}{2} \text{ of } \frac{1}{10} = \frac{1}{20} \text{ or } .05\right)$ gives results comparing quite favorably with gravimetric analysis.

Slightly more than 17.5 c. c. of acid may be used to advantage when testing skim-milk ; it is also advisable to increase the speed of the tester or the length of time it is whirled.

The fat column in a double-necked bottle may be raised to any desired point on the scale by gently pressing with the finger on the mouth of the large neck.

It is not necessary to use quite the full amount of acid when testing whey.

The ordinary milk bottle is not suitable for testing skim-milk, butter-milk or whey, as it is almost impossible to make an accurate reading of such a small amount of fat when it is extended over a broad surface.

TESTING CREAM.

Special forms of bottles have been devised for testing cream by the Babcock test. The most satisfactory cream bottle has a neck of the usual length and sufficiently wide to allow a measurement of 30 per cent. of fat; 18 grams of cream are used, and the test completed in the usual way.

Note. In testing cream, slightly less acid is required than for milk.

If the cream be measured with a 17.6 c. c. pipette, the result will be too low, for two reasons:

(1) The specific gravity of cream is lower than that of normal milk; therefore a given measurement will weigh less than the same measurement of milk.

(2) Cream is more viscous than milk. Hence more of it adheres to the sides of the pipette, and this amount in thick and sour cream is sufficient to change the results materially.

As the specific gravity of average cream is about 1, an 18 c. c. pipette will deliver approximately 18 grams—the amount required for a test of cream or milk.

To test cream, using the ordinary test bottle:

1. By means of a 6.04 c. c. pipette, take six grams of cream. With the same pipette deliver to the test bottle 12 grams of water; this will rinse out the cream adhering to the sides of the pipette and cause the entire measurement of cream to be delivered to the test bottle.

Add the required amount of acid and proceed as in testing milk. Multiply the reading by 3 to obtain the percentage of fat.

Note. The scale on the neck of the ordinary test bottle is graduated to read directly the per cent. of fat, only when 18 grams are used in the test, *i.e.*, the fat extending over one of the larger divisions of the scale weighs *one per cent.*, or the one-hundredth part of 18 grams. This fact will explain the various rules for determining the per cent. of fat when 18 grams cannot be used in a test—as in the case of cream and cheese, in which the per cent. of fat is high.

Rule. To find the per cent. of fat when less than 18 grams has been used: multiply the reading obtained by 18 and divide by the number of grams used.

Weighing any suitable number of grams (from 4 to 6) of cream for a test and making up the rest of the 18 grams with water, is the most accurate method. This requires a delicate balance and weights of the metric system.

TO TEST CHEESE.

Obtain a representative sample of cheese by taking a plug extending from near the outside well to the centre of the cheese; cut this into small strips extending from end to end of the plug—strips that will pass through the neck of the test bottle. Weigh from 4 to 5 grams and put into the test bottle; add to this from 12 to 14 c. c. of *hot* water to dissolve the cheese. Should difficulty be experienced in getting a thorough solution, the addition of a small amount of some alkali, such as potash or ammonia, will facilitate the operation. After agitating the contents of the test bottle sufficiently to cause a thorough solution of the cheese, cool the sample to between 60 and 70° F., add the usual amount of acid, and proceed as in testing milk $\frac{\text{Reading} \times 18}{\text{grams used}} = \text{per cent. of fat in sample tested.}$

The Lactometer and the Detection of Adulterations in Milk.

The lactometer is an instrument used to determine the *specific gravity* of milk. The term specific gravity means the weight of a certain volume of any substance compared with the weight of the same volume of pure water.

There are different kinds of lactometers, but the Quevenne is the most suitable for milk-testing. By means of it, we can determine rapidly the relative weight of milk and water.

The Quevenne lactometer is standardized at a temperature of 60 degrees; if the milk to be tested varies from this, corrections may be made according to the following rule: For each degree in temperature *above* 60, add .1 ($\frac{1}{10}$) to the lactometer reading, and for each degree *below* 60, subtract .1 ($\frac{1}{10}$) from the lactometer reading. This rule is practically correct, if the temperature is kept within a range of from 50 to 70 degrees. It can be readily recalled when we remember that the density of milk *increases* with a *reduction* of temperature and decreases with a rise in temperature. The scale on the lactometer is graduated from 15 to 40, and indicates a specific gravity of from 1.015 to 1.040.

Note. The correct lactometer reading (or L.R. at 60 F.) + 1000 ÷ 1000 indicates the specific gravity.

The lactometer reading of whole milk usually ranges from 29 to 33, although it may fall as low as 27, or go as high as 34 or 35. The lactometer reading of skim milk varies from 33 to 38. The reading should be taken soon after placing the instrument in the milk; if cream be allowed to rise on the milk, the reading will be too high, as the bulb of the lactometer will be floating in partially skimmed milk. Milk should be cooled and allowed to stand some time (1 to 3 hours) after being milked before taking the lactometer reading. Otherwise the readings will be too low.

The composition of milk is about as follows:

Fat.....	3.6	per cent,		
Casein.....	2.5	" "		
Albumen.....	.7	" "	} 8.9	Solids, not fat.
Sugar.....	5.0	" "		
Ash.....	.7	" "		
Water.....	87.5	" "		
	100.0			

It is the solids-not-fat in milk that cause its specific gravity to exceed that of water, and consequently its lactometer reading to be greater than that of water.

A number of different formulas have been prepared for the calculation of milk solids when the lactometer reading and percentage of fat are known. As the percentage of solids-not fat increases .25 per cent. for each lactometer degree and .2 per cent. for each per cent. of fat, the following formula has been very generally adopted:

$\frac{L}{4} + .2 \text{ fat}$. To find the *total solids* in a sample of milk,—add $\frac{1}{4}$ of the lactometer reading to 1.2 times the per cent. of fat.

The following rule is sufficiently accurate for practical purposes and has simplicity to recommend it: To determine the per cent. S. N. F., add the correct lactometer reading and per cent. fat together, and divide by 4. $\frac{L+F}{4} = \% \text{ S. N. F.}$

ADULTERATIONS.

By the use of the Babcock test in conjunction with the lactometer, we are enabled to determine both the nature and the extent of an adulteration.

The percentage of fat in milk varies and can also be influenced by skimming, therefore it alone is of little use in determining adulterations. The solids-not-fat are fairly constant and thus afford a means of detecting adulterations.

Watered Milk. To find the per cent. of pure milk in a watered sample, multiply the per cent. S.N.F. in it by 100, and divide by the per cent. S.N.F. in the pure milk. This subtracted from 100 will give the per cent. of extraneous water in the watered sample. To take an example:

The per cent of solids-not-fat in a sample of pure milk is 9; but after being watered the per cent. of solids-not fat in the watered sample is 7.2. Find the per cent. of pure milk in the watered sample.

Per cent. of pure milk in watered sample = $\frac{7.2 \times 100}{9} = 80$ per cent.

Per cent. of extraneous water = $100 - 80 = 20$ per cent.

Note: When a sample of the pure milk cannot be obtained, use 8.5 in the early part of the season, and 9 in the latter part, for the per cent. S.N.F. in pure milk.

NOTES.

1. Have the temperature of the milk uniform throughout, and as near sixty degrees as possible when taking a lactometer reading.
2. Always mix the milk well before taking a lactometer reading.
3. Do not have milk on the upper part of the stem of the lactometer when reading, as this weighs the lactometer down and causes the reading to be too low.
4. Have the lactometer free from the side of the vessel, and perfectly still, when taking a reading.
5. A high lactometer reading accompanied by a low per cent. of fat indicates skimming, e. g., $L = 34$, $F = 2.4$.
6. A low lactometer reading accompanied by a low per cent. of fat, is indicative of watering, e. g., $L = 22$, $F = 2.4$.
7. A normal lactometer reading with a *very* low per cent. of fat indicates both watering and skimming. Also, if the lactometer reading of a sample of milk be low, yet not so low accordingly as the per cent. of fat, this is indicative of both watering and skimming. Both of the following indicate watering and skimming: $L = 31$, $F = 2$; $L = 26$, $F = 1.8$.

COMPOSITE SAMPLES.

In separator creameries, and in many of the more advanced cream-gathering creameries and cheese factories, the patron receives payment, not in proportion to the amount of milk, but in proportion to the butter or cheese value of the milk supplied by him. Such a system, of course, necessitates the use of the Babcock test. A test of the milk cannot be made daily; and to overcome this difficulty a small sample of the milk supplied by each patron is taken at each time of delivery and put into a bottle, called a *composite sample bottle*, which contains a small amount of some kind of preservative—such as bichromate of potash or corrosive sublimate. It is not advisable to use the latter alone, as it is quite poisonous, and imparts no color to the sample to indicate its presence in it. An excellent preservative is a mixture composed of about seven parts bichromate of potash to one part corrosive sublimate.

From what can be taken on a five-cent piece to what can be taken on a ten-cent piece will usually be found sufficient to preserve a sample for two weeks in summer, and a month in fall and winter, when an ounce of milk is taken daily. The amount of preservative required depends upon the weather, the size of the samples, and the length of time over which the testing period extends. A Babcock test of the sample is made at the end of two weeks or a month; and if the daily sampling and the testing of the sample are carefully done, it gives the average quality of the milk supplied during the time over which the test extends.

The samples may be tested twice per month, but by keeping them in a fairly cool place satisfactory results can be obtained by testing but once a month.

NOTES ON COMPOSITE SAMPLING AND TESTING.

1. For holding composite samples, pint jars with long corks are preferable. Turned wooden corks are more satisfactory than porous corks.

2. The jars should be kept well corked, as the samples will dry on the surface and a tough skin, composed largely of cream, will be formed when exposed to the atmosphere in warm weather.

3. Paste a plainly written label on each patron's jar, fasten its edges down well, and give it at least two coatings of heavy shellac to prevent it from washing off when cleaning the bottles.

4. Add the preservative to the composite sample jars at the beginning of the testing period, and before any milk is added to them. It may be necessary to add a little extra preservative later on. Be guided by the color of the samples and how well they are keeping. An excess of preservative has a strong tendency to produce burnt readings.

5. The sample for the composite jar should be taken after the milk is poured into the weigh-can. For this purpose an ounce or a half-ounce dipper is often used. A tube or milk "thief" and a drip from the conductor are also satisfactory means of obtaining a sample. When receiving milk that is partly frozen, guard against taking a sample from only the unfrozen portion.

6. Give the jar a gentle rotary motion each time a sample is taken, to mix with it the cream that has risen and also to incorporate the fresh sample with the part containing the preservative; and avoid shaking the jar, as shaking tends to churn the contents.

7. It is sometimes necessary to place the samples in a cool place each day when through using them.

8. To prepare composite samples for testing: Set the sample jars in warm water at about 110° F., to loosen the cream from the sides of the jars, and also to warm the samples to cause the cream that has risen to mix more readily with the milk. Mix well by pouring from one vessel to another—never by shaking. Should difficulty be experienced in getting a thorough solution, the addition of a small amount of potash will facilitate the operation.

When the composite samples for the Babcock test have been added to the test bottles, cool to about 60° F., before adding the acid. One of the points most frequently neglected and underestimated is attention to temperatures. Sulphuric acid acts more strongly upon milk that is at a high temperature, than upon milk at a lower temperature; also the higher the temperature the more the fat will expand and the greater the reading will be. Adopt some *constant* temperatures for each step of the work; the following have been found very satisfactory: About 60° for the milk when the acid is added, about 140°

for the water added to the test bottles, and between 130° and 140° for the water into which the test bottles are set before a reading is taken. If you prefer different temperatures from those suggested, adopt them, but do not neglect to adopt *constant* temperatures.

Add the water to the test bottles at twice rather than all at once, filling each bottle just to the neck at first, and to about the eight per cent. mark the second time. Whirl the tester for a minute after each addition of water.

9. Cost of testing composite samples: In a gallon of sulphuric acid there is enough for about 260 tests. Estimating the value of the acid to be $3\frac{1}{2}$ ¢ per pound, the cost of the acid for a single test would be one-quarter of a cent.

To find the average test of a number of samples: If the weights and tests of a number of different lots are fairly uniform, the average weight and test may be found by dividing the sum of the weights and tests by the number of lots, but when there is *no uniformity* in the different lots, the *true average* test can be obtained only by multiplying the total pounds of fat by 100 and dividing the product by the total pounds of milk. There is sometimes a wide difference between the mathematical average and the true average test of different lots.

THE OIL TEST.

This is a churning process for the purpose of ascertaining the richness of cream, which is used mostly in cream gathering creameries. The cream gatherer is supplied with a pail 12 inches in diameter in which the depth of cream supplied by the patron should be carefully *measured*. After thoroughly mixing the cream the gatherer should take a representative sample, filling the test tubes carefully to the mark, which should be five inches from the bottom.

TO MAKE AN OIL TEST. Upon their arrival at the creamery, place the samples in a warm place, as over the boiler, and leave over night to ripen thoroughly. *They will not churn properly unless well ripened.*

The next morning, place the samples in water at a temperature of about 90 degrees; and as soon as the cream will flow freely from one end of the tube to the other, place in the oil test churn and begin the churning. Should the cream at any time cool and thicken, place the samples in warm water to liquefy the cream again. Continue churning until there is evidence of a clear separation of the fat; then place the samples in hot water, at a temperature of from 160 to 170 degrees, for from fifteen to twenty minutes.

If the separation be complete, the fat will be clear and yellow, and there will be three distinct columns with sharp lines of division between them, viz., a column of clear fat on top, one of whey next, and one of curdy matter at the bottom. If there be not a clear separation, cool to about 90 degrees, churn again and proceed as before.

TO TAKE A READING. There is a chart prepared for the purpose. Placing the bottle in an upright position on the "base line" of the chart, move it along until, when looking by the right side of the bottle, the top of the column of fat comes even with the uppermost slanting line on the chart. Next, still looking by the right side of the bottle, observe the line to which the bottom of the fat comes; the number on this line gives the reading.

A small rule made specially for the purpose is more convenient than a chart. This, however, will give an accurate reading only when the test-tubes have been filled precisely to the mark. The chart consists of a sliding scale and gives the proportion of oil regardless of the depth of cream taken in the test-tubes.

Sometimes the fat, though clear, is somewhat open. In such cases or when the fat is not clear, allow the samples to become cold, and then place in water at a temperature of about 120°F , before taking a reading. About 120 degrees is a very suitable temperature at which to take readings.

MEANING OF THE READING. Cream that gives a reading of 100 in the oil test will make one pound of butter for every inch of such cream in a cream pail 12 inches in diameter; cream testing 120 will make 1.20 pounds of butter per inch. To find the pounds of butter, multiply the number of inches by the reading and divide by 100.

THEORY OF THE TEST. A standard or creamery inch is one inch of cream (in a twelve inch pail) testing 100.

One inch, therefore, contains 113 cubic inches. One pound of butter contains about 25 cubic inches of butter oil, which is 22 per cent. of 113. Therefore any cream which will yield 22 per cent. of its volume in butter oil, will yield one pound of butter per inch. Tubes filled to the depth of 5 inches with cream which gives 1.1 inches of butter oil, will yield one pound per inch, as 1.1 is 22 per cent. of 5.

THE ALKALINE SOLUTION: ITS PREPARATION AND USE.

BY R. HARCOURT, B. S. A., ASSOCIATE PROFESSOR OF CHEMISTRY.

CAUSES OF ACIDITY IN MILK. The development of acid is caused by the breaking down of milk sugar into lactic acid, through the influence of certain acid-forming ferments in the milk. But even sweet milk, immediately after it is drawn from the udder, will have an acid reaction with certain indicators. This acidity is not due to lactic acid nor any free acid in the milk, but to the acid nature of the ash constituents, and possibly also to the carbonic acid gas it contains and to the acid nature of the casein. When phenolphthalein is used as an indicator, freshly drawn milk will usually show as much as .10 per cent. of acid; and immediately after exposure to the atmosphere, lactic acid germs commence breaking down the milk sugar. At a temperature of 70° to 90°F ., these germs multiply at an enormous rate; consequently lactic acid will develop very rapidly in milk during a warm or sultry day or night. Cooling retards the action, but even at a temperature of 40° to 50°F ., they will multiply and considerable lactic acid will be formed. Milk intended for cheese-making should not contain more than .20 per cent. acid when delivered at the factory; whereas, it does not usually smell or taste sour until it contains .30 to .35 per cent. A further development of acid will cause the milk to curdle, or, in other words, will produce coagulation of the casein. There is, however, a limit to the development of acid; for after a certain point, the germs which break down the milk sugar are destroyed by the acid they produce, and there is no further increase in acidity.

In many ways a knowledge of the acid contents of milk or its products is of value. In most cases, a determination of the per cent. of acid in the milk when delivered at the factory will indicate the care the milk has received previous to that. Some attempts have been made to make use of direct acid tests in controlling various steps in the manufacture of cheese; but no definite con-

clusions have been reached as yet. The acid test may also be of value in selecting milk best adapted for pasteurization, or for retail trade, or manufacture of high-grade products. At the present time, however, the chief use made of acid tests is to determine when cream is ripe enough for churning. The ripening of cream is largely a development of lactic acid, and is hastened or retarded according to the temperature at which the cream is kept. Knowing the per cent. of acid in the cream and the per cent. of acid at which he wishes to churn, the operator can handle the cream so as to have it in about the same condition day after day, and thus produce a uniform article of butter.

HOW TO MEASURE THE ACIDITY. The measurement of the amount of acid or alkali in a solution depends upon the fact that it always takes a definite quantity of alkali to neutralize a definite quantity of acid. Thus, for instance, it always takes a definite quantity of caustic soda to neutralize a definite quantity of lactic acid, sulphuric acid, or any other acid. If, then, we know the strength of a given caustic soda solution and measure the amount of it used to render milk or cream neither acid nor alkaline, but neutral, we can figure the amount of acid in the sample taken. To make such a determination we require the following :

1st. A standard solution of caustic soda, usually made of the strength known as one tenth normal.

2nd. An indicator—some chemical which added to the milk indicates by change of color when enough of the alkaline solution has been added to render the milk neutral. Phenolphthalein is the one most commonly used for this purpose. It is made by dissolving 10 grams of phenolphthalein in 300 c.c. of 80 per cent. alcohol.

3rd. A burette, graduated to 1-10 of a cubic centimeter, in which to measure the amount of solution used.

4th. A pipette, to measure the milk or cream.

5th. A glass or porcelain cup, and a stirring rod.

PREPARATION OF SOLUTIONS. The caustic soda solution may be prepared by a druggist or one who has a delicate balance at hand by carefully weighing out 4 grams of pure sodium hydroxide and dissolving in one litre (1000 c.c.) of water. But impurities in the sodium hydroxide and lack of delicate enough balance make this method unreliable.

The most accurate way of preparing this solution is by standardizing it against an acid diluted to the same strength as the alkaline solution wanted. As it requires an experienced chemist to prepare this acid of the strength required, we will undertake to supply it at a nominal cost of 25c. per bottle.

Having on hand then a one-tenth normal solution of acid, the object is to make a solution of the alkali, one c. c. of which will exactly neutralize one c. c. of the acid. For this purpose, dissolve about 5 grams sodium hydroxide (NaOH) in one litre of water. If the soda contains much carbonate, it must be removed by adding a little of a solution of barium hydroxide, boiling, and filtering off the precipitated carbonates. The relative strength of the acid and alkali solutions is next determined. This is done as follows :

Rinse out the clean burette two or three times with the acid solution, and then fill it with the same. Note the exact point at which the surface of the liquid stands in the burette ; measure out 10 c. c. of the alkaline solution, and deliver into a clean beaker, glass or porcelain cup. Dilute with about 50 c. c. of water, add three or four drops of the phenolphthalein indicator, and then, stirr-

ing all the time let the acid from the burette drop slowly into the alkaline solution, until the color first produced by the indicator is just destroyed. This is the neutral point. Now, again note the exact point at which the surface of the liquid stands in the burette. The difference between the two readings is the amount of acid required to neutralize the 10 c. c. of alkali. If care be taken in coming to the neutral point slowly, it will be seen that one drop finally destroys the last of the light pink color. This work should be repeated until accuracy is assured. The following is an example of results:

1st.	10 c. c. of alkali required	11.5 c. c. of acid for neutralization.			
2nd.	10 c. c.	"	11.45	"	"
3rd.	10 c. c.	"	11.5	"	"

In this case, we would accept 10 to 11.5 as the relative strength of the two solutions. The alkali is, therefore, the stronger, and must be diluted. If 1.5 c. c. of water be added to 10 c. c. of the alkali solution, 1 c. c. of the alkali ought exactly to neutralize 1 c. c. of the acid. Therefore, for every 10 c. c. of the alkali solution add 1.5 c. c. of water. Measure out the amount of the solution, and pour into a clean dry bottle. Calculate the amount of water required to dilute the alkali solution to the proper strength, and add it to the contents of the bottle. Mix well, and test correctness of work by proving that 10 c. c. of the one solution will exactly neutralize 10 c. c. of the other. If it does this, the solution is correct.

TESTING THE ACIDITY OF MILK OR CREAM. By means of a pipette (a 10 c. c. is a convenient size), measure out a definite quantity of the milk or cream to be tested and deliver into a beaker or cup. If distilled or rain water is handy, rinse out the pipette once and add the rinsings to the sample. Dilute with 50 c. c. of water, and add three or four drops of the indicator. Now, having the alkaline solution in the burette, carefully note the point at which the surface of the liquid stands in the burette and then cautiously let it drop into the milk or cream being tested. Keep the sample well stirred while adding the alkali. The acid in the sample will be gradually neutralized by the alkali added, until at last a uniform pink color appears, which will slowly fade away. The most delicate point is the first change to the uniform pink color, which the sample shows when the acid contained therein has been just neutralized. Because of the influence of carbonic acid of the atmosphere, the pink color is not permanent unless a large excess of alkali solution has been added. The operator should not, therefore, be lead to believe by the disappearance of the color after a short time, that the neutral point has not been reached. Having decided on the neutral point, again read the burette at the surface of the liquid, and the difference between this reading and the first is the amount of alkali solution used to neutralize the acid in the sample taken. The per cent. of acid is calculated by multiplying the number of c. c. of alkali used by .009 and dividing the product by the number of c. c. in the sample taken, and multiplying this by 100.

Per cent. of acidity— $\frac{\text{c. c. of alkali} \times .009}{\text{c. c. of sample}} \times 100$

Example. If 25 c. c. of cream require 16.5 c. c. of alkali solution to produce a uniform pink color, the per cent. of acid in the cream will be $\frac{16.5 \times .009}{25} \times 100 = .59$ per cent. When a 10 c. c. pipette is used a part of the calculation may be saved. Simply multiply the number of c. c. of alkali solution used by .09. For example: It requires 6.6 of alkali solution to neutralize 10 c. c. of cream; therefore $6.6 \times .09 = .59$ per cent. of acid.

To insure accuracy the utmost care and cleanliness must be observed in every detail of the work. All water used with the milk or cream or in making the alkaline solution should be either distilled or pure rain water. The burette and pipette, after being washed, must be rinsed out two or three times with the solution they are intended to measure.

The knowledge the operator may gain from such tests will not only make it possible for him to turn out more uniform products; but it will also enable him to act with confidence and more intelligently to pursue the work he may have on hand.

Recognizing the value of the alkaline solution to the factory man and the difficulty he has had in obtaining it, the Chemical Department offers, this year, to furnish the solution to those who may want to make use of it. To cover cost of bottle, material, etc., we shall be obliged to charge \$1 per gallon for the solution. Where 10 c. c. of milk or cream is used for the test, one gallon of the solution will make about 400 tests. The money must be sent with the application, which should be made to R. Harcourt, Chemical Department, Ontario Agricultural College, Guelph.

SEPARATORS AND THE SEPARATION OF MILK

BY MARK SPRAGUE, INSTRUCTOR.

Separators are divided into two classes—the steam or turbine, and the belt separator. The former is driven by steam direct from the boiler, and no engine, shafting, or belting is required to propel it.

TURBINE SEPARATOR. In setting it up, a solid foundation should be provided, by excavating to a solid bottom. The nature of the soil will determine the depth, and the size of the frame or base of the separator, the length and breadth. After placing the templets, which should be at least one foot longer than the length of the separator base, long bolts should be provided—the length to correspond with the depth of the excavation—care being taken to have the tops of the bolts come exactly even with the wood capping which is placed on the foundation. See that anchor plates are provided for each bolt and in place; then fill the excavation with stone, brick or grouting. Bricks are neatest, but should be plastered with a strong coating of cement to prevent milk or oil from being absorbed by them. Place the separator upon the foundation, bolting it securely to the wood capping of the foundation with lag or wood screws, using great care to have the separator frame perfectly level every way. Determine this by placing the spirit level upon the planed top of the frame. Test the level to be sure that it is accurate by turning it from end to end in the same place, and note if the bubble comes to rest at the same point.

The pipe to convey the steam to the separator may be the same size as the fittings of the separator, provided the distance from the boiler is not over twenty-five feet. When there is more than this distance, the size of the pipe should be one-quarter inch larger for every twenty-five feet of piping, to overcome friction and condensation of steam.

Exhaust pipes are usually made of galvanized iron, and should never be reduced in size at any point, smaller than the outlet on the separator, and should be put up as straight as possible to convey the steam from the separator. It may

be carried out at the side of the building or under the floor, if extended to the side of the building. In either case, a piece extending upwards should be put up to cause a draught. Placing the exhaust pipe out through the roof is preferable when the surroundings will permit of it. Have the pipe long enough to be higher than any part of the roof, in order that the draught may not be interfered with by change of wind. A drain pipe must be provided in any case at the lowest point on the pipe, to allow water to escape readily. If this should be in the making-room, a trap to prevent annoyance from escaping steam may be put on the drain pipe.

BELT SEPARATORS. The directions given for a foundation for the turbine separator will apply to this. Many of the directions published say, "No special foundation is required." Our experience is that "the smoother the road, the longer and better the waggon will run"; and a similar statement might be made regarding cream separators. It does not matter how solid a floor is, it will vibrate more or less from the running of a churn or other machinery. With a stone, brick, or concrete foundation, a separator is independent of any vibration from other machinery and will run much better, and for a longer time.

First, place the intermediate or jack in position. Level it by placing a spirit level perpendicularly on the planed rim of the separator pulley of the intermediate. Be sure to have the shaft of the intermediate parallel with the driving or main shaft. Then fasten it in position with bolts, bearing in mind that to run well, it should be at an angle of 45 degrees in front or behind the driving shaft. The pulley provided for the driving shaft should be of sufficient width to allow the belt to be shifted from the tight to the loose pulley of the intermediate, and of the proper size to give the exact speed required.

Next, place the frame of the separator in position. Level it in all directions by placing the level on the planed top of the frame. Line the separator with the intermediate, by bringing the right hand outside surface of the spindle pulley in line with the centre of the face of the intermediate pulley, having the vertical centre line of the spindle pulley level with the underside of the intermediate pulley. Then bolt the separator securely to the foundation, unless it be one that has the spindle and bowl connected by socket bearing. These are supplied with an independent bed plate, and only the plate requires to be securely bolted to the foundation.

The separator bowl should revolve to the right, or with the sun, the same as the hands on a watch. The intermediate should run from the separator, so as to place the draw belt on the upper side of the intermediate pulley, with a view to remove the weight of the bowl from the foot-step bearing when the separator is running. If an idler or belt-tightener is used, always place it on the "return" side of the belt—*never* on the "draw" side.

Wipe all the bearings well with a cloth, to remove all grit and dust. A little coal-oil upon the cloth will be found helpful where any coating of dried oil is met with. See that all oil tubes are clear and free to feed the oil. Wash the bowl and all parts that the milk comes in contact with. If everything has been properly attended to as directed, it is ready to start. If a turbine, fill the bowl with water to keep it in balance. Turn on steam very gradually to allow the water to get out of the steam pipes, when the required amount of steam may be turned on. When speed has been reached, start the feed of milk.

If a belt machine, and only one is used, put all belts in position, and start the engine slowly, allowing the speed to increase gradually. If more than one

separator is used, it is better to start the engine at full speed, then shift the belt from the loose to the tight pulley after starting the separator by pulling the belt with the hand until the bowl has attained some speed. Then shift the belt from the loose pulley part way on to the tight pulley, moving it at intervals until on full. From five to seven minutes should be required to get up speed. Full speed is ascertained by means of the speed indicator. A 100 notch wheel should be counted for one minute, and a 50 notch wheel for one-half a minute, in order to know the number of hundred revolutions the bowl is revolving per minute. After speed has been reached, the milk should be turned on full feed, until both cream and skim milk flow from the respective spouts; then it should be closed off until the cream is of the desired thickness. The cream should be the guide in operating the separator.

The cream left in the bowl when all the whole milk has been put through may be forced out with either skim-milk or warm water. From one to two pails will be needed for this purpose. Shut off the feed-tap for a few seconds when about half the quantity has gone through; then turn it on again allowing the remainder to complete the operation. Pure warm water is preferable to skim-milk, as it is nearer the specific gravity of the cream, and consequently displaces it more readily.

Allow the bowl to stop of its own accord after the power has been removed; never apply any brake or friction to the intermediate. Remove the solid matter found at the extreme outside of the bowl and burn it at once. Clean out all milk tubes with the spiral provided; wash with tepid water thoroughly; scald with steam or boiling water; and allow the bowl and its parts to dry, when it may be put together for the next day's operation.

Milk fresh and warm from the cow is in the best possible condition for a perfect separation. The difference in specific gravity between the fat and other portions of the milk is then greatest, and it is also more fluid, as there is no development of lactic acid, nor chemical changes due to its exposure to the air. At the creamery, it is not met with in this favorable condition; consequently it is necessary to produce artificially as many of the favorable conditions as possible, to get the best results. When milk is received at a temperature below 85 degrees, it should be heated to as near 98 degrees as the condition of the milk will permit.

A tempering vat should be elevated at a suitable height to allow the milk to flow into the separator; and it should contain enough milk to employ the separator for at least four minutes. If large bodies of milk are heated to the desired temperature in a vat before separating, acid develops too rapidly and clogging of the separator bowl is likely to follow. Should any accident happen whereby the separator would be stopped, the milk would likely develop acid enough to thicken, when it could not be separated.

Heating milk by means of an ejector or steam turned directly into the milk will produce the desired temperature, but poor results will follow this method. Proper time for the fat of the milk to expand is not allowed; and if time is allowed, the steam used to effect the heating is condensed and mixes with the milk. Condensed steam and cream are nearly of the same specific gravity, and would flow from the separator together from the cream spout. The total amount to be separated would be increased by the steam so condensed, and the cream would be made thinner than it should be, which would make it necessary to lessen the feed of milk and reduce the capacity of the separator, which is not

desirable. In the winter months, pasteurizing the whole milk before separating gives the best results. The objectionable flavors are largely removed and the high temperature (160 degrees) produces all the favorable conditions that are to be had from heating milk before separating it.

PULLEYS AND BELTING. The following rules for finding the size of pulleys, and the required length of belting will be found useful, in fitting up a creamery or in placing additional machinery.

To find the diameter of a driven pulley, multiply the diameter of the driver by its number of revolutions, and divide the product by the number of revolutions the driven pulley should go. The result will be the diameter of the driven pulley.

Example: Diameter of pulley on the engine, 40 inches; speed of engine, 160 revolutions; speed in main shaft, 200 revolutions; $40 \times 160 \div 200 = 32$, which is the diameter in inches required for the driven pulley.

To find the required size of a driving pulley, multiply the diameter of the driven pulley by the number of revolutions it should make, and divide the product by the revolutions of the driver.

Example: Diameter of the pulley on intermediate is 4 inches, which is required to run 900 revolutions per minute. Revolutions of shaft 200. $4 \times 900 \div 200 = 18$, which is the diameter in inches of the pulley required to drive the intermediate at proper speed.

To find the length of belt for any two pulleys, add the diameter of the two pulleys together, divide their sum by 2, and multiply their quotient by $3\frac{1}{4}$. Add the product to twice the distance between the centres of shafting, and the result will be the required length of belt.

Example: Two pulleys are 8 and 24 inches in diameter, and 8 feet is the distance between the centres of the shafting. $8 + 24 = 32$, $32 \div 2 = 16$, $16 \times 3\frac{1}{4} = 52$ inches = 4 feet 4 inches, and 4 feet 4 inches + 16 feet (twice the distance between the centres of the shafting) = 20 feet 4 inches, which is the length of belt required.

BUTTER MAKING.

BY JAS STONEHOUSE, INSTRUCTOR.

As butter is one of the most delicate and perishable of our table foods, extra care and intelligence are necessary in its preparation. A knowledge of the composition of milk and cream and of the very important part which different kinds of bacteria play in the production of good and bad butter, is necessary before we can intelligently apply the principles which underlie the manufacture of this wholesome and nourishing part of our daily food.

CLEANLINESS. Cleanliness is of so much importance in the manufacture of butter that it must always take first place, not only during the process of manufacturing the finished product, but at every step from the very beginning, even before the milk is drawn from the udder of the cow,—so important that, with absolute cleanliness in every detail of the work, we can turn out an excellent product with the crudest of appliances, while, without it, we may have the very best of everything and our efforts will meet with very indifferent success.

The creamery manager has much yet to do in the line of instructing his patrons in cleanliness, and it is largely to his influence that we must, in the future, look for improvement; but before attempting to lead others in the way they should go, he should see to it that his own house is set in order, for example is stronger than precept.

We have arrived at a stage of our butter industry where it is very necessary that we should have more uniform methods of handling the milk or cream before they leave the farm. It is there, to a great extent, that the flavor of our butter is made or marred; and as it is the flavor which largely determines the value of butter, the flavor of the milk is of the first importance; therefore all milk should be subjected to a close inspection before being received at the creamery, and if any is considered unfit for the purpose of butter-making, it should be rejected.

Milk in its natural condition, as it is drawn from the udder of a healthy, well fed cow, is, with proper care, in the very best condition to give the flavor or aroma which is so desirable in good butter.

Tainted milk may be treated in various ways, such as pasteurizing, to improve the flavor, yet, butter from such milk always lacks the full, pleasant flavor which is a characteristic of butter made from milk in its natural condition.

SEPARATOR CREAMERIES.

TAKING IN THE MILK. The man at the weigh-can occupies the position of inspector and should know what to accept and what to reject; for upon his judgment, to a great extent, depends the flavor of the butter. He has also to deal justly with the patrons in the matter of taking composite samples of milk and in giving correct weights.

Note. If milk is rejected as unfit to make good butter, the creamery manager should, when necessary, aid the patron in tracing the cause of the taint and in applying a remedy.

Milk, as it enters the vat, should be strained through two-ply of strainer cloth.

CREAM RIPENING. The proper ripening of the cream is one of the most important factors in making good butter; and the butter-maker should be supplied with proper facilities for controlling the temperature.

To get the best results, cream must be ripened evenly; and this can be done only where the cream is well surrounded by the cooling or heating medium.

Note. The round-bottomed vats, with a 6 in. space on each side and 16 to 18 in. at one end, are the best open cream vats now made.

A good, clean-flavored culture is almost a necessity where uniform ripening and flavor are desired. Quick ripening, at a fairly low temperature, can be secured with the aid of 10 to 20 per cent. of culture; and a better body in the butter can be obtained in this way.

Where the milk or cream is not pasteurized, and the supply of milk is fairly constant, and it is advisable to put the culture in the cream vat before separating commences; as by doing this, it gives the culture a better chance to do its work. The amount of culture to be used must, to a great extent, be left to the butter-maker's judgment, as the ripening temperature, and the time the cream is to be held, determine the amount to be used.

Where the cream is ripened at 65° F., 15 per cent. of culture can be advantageously used.

Cream should be frequently stirred while the ripening process is going on, in order that the ripening may be uniform. Keep the temperature fairly constant until the alkaline test shows about .4 per cent. of acid, at which point the cream is about to thicken. The cream should then be cooled rapidly to near the churning temperature, where it may be safely left over night, surrounded by water cold enough to bring it to the churning temperature before churning time, when it will usually show from .5 to .6 per cent. of acid.

Note. The acid or alkaline test is for the purpose of determining the acidity or sourness of the cream, which should be fairly constant from day to day if a uniform flavor in the butter is desired. This test also assists us in training our sense of taste and smell in judging the acidity of the cream.

PASTEURIZING. Where a constant supply of good milk cannot be depended upon, many creameries now pasteurize the whole milk before separating. This method has the advantage of giving a good keeping quality to the skim-milk, and at the same time pasteurizes the cream. It also makes the milk more fluid, thus causing it to skim more easily and flow more readily into the separator, thereby increasing the capacity of the separator.

A higher temperature can be maintained by heating the whole milk, without imparting a cooked flavor to the cream, which is an important point to bear in mind, as better results have been obtained from a much higher temperature than is usually recommended for pasteurization of cream. Milk may be safely heated to 185° or 190°, if we have the appliances; and this high temperature improves the keeping quality of the butter. Where the cream only, is pasteurized, it is doubtful if, with our present facilities, we can safely reach those high temperatures without injuring the flavor; and we are liable to have a scum of cooked albumen and casein rise to the surface of the cream, especially if the cream be pasteurized in bulk, as in a cream vat. Whatever method is followed in pasteurizing cream, it is very necessary to keep the cream constantly in motion to prevent the casein from adhering to the sides of the vessel. Rapid cooling of pasteurized cream is very desirable; and for this purpose, the Lister cooler is an excellent arrangement, as it cools the cream almost instantly from 160° down to the ripening temperature, if the supply of water is below 60°.

Note When we speak of the ripening temperature of cream, we speak of no fixed temperature, because there are so many different conditions which affect the ripening. For cream to be churned in 24 hours, 65° to 70° is a suitable range of temperature. For cream to be held for 48 hours, the ripening temperature should be lower—about 55°.

Pasteurized cream is treated similarly to raw cream, except that the ripening temperature may be a few degrees higher, or a larger amount of culture may be added. The germ content of the cream having been destroyed by pasteurization, we have, practically, a sterile cream, and by adding an extra amount of culture which contains the kind of germs to give the desired flavor, we thus have the flavor of the cream and butter very much under our control.

Note. While pasteurizing is a great help in handling tainted milk and cream, it cannot be depended upon to remove all flavors which contaminate milk; therefore it would seem a more rational and business-like course, to educate the patrons to remove the cause, rather than to encourage them in their careless methods of handling milk, by trying to remedy the evil at the other end. Pasteurized butter, undoubtedly, has excellent keeping qualities, and pasteurizing the whole milk may be extensively practised in the near future; but the practice

should not be made compulsory by allowing slovenly methods of handling the milk before it leaves the farm.

CHURNING. Cream may be churned either sweet or sour ; but sour, or ripened, cream, is usually the more easily churned, and it yields, when the ripening has been properly done, a butter of better keeping properties. The temperature at which churning may commence, under ordinary conditions, may vary from 48° to 70° . The proper temperature for churning cream can be determined only by the time taken to bring the butter into the granular form, which should be from 30 to 45 minutes. There are several factors which influence the churning temperature of cream, the most important of which are : the percentage of fat in the cream, the period of lactation of the cows, the feed of the cows, and the amount of cream in the churn.

The fat content of the cream is the most important ; and if we know what per cent. of fat the cream contains, we can, under ordinary conditions, determine beforehand at what temperature to commence the churning, in order to have the butter come in the desired time.

To get the best results, the per cent. of fat should range from 25 to 35 according to the season of the year. Thirty-five per cent. cream will usually churn, without trouble, at 50° during the flush of the spring season. The per cent. of fat, will, however, have to be lowered as the season advances and the churning temperature correspondingly raised. A high per cent. of fat in the cream admits of a low churning temperature and gives the most exhaustive churning.

The churning should cease when the granules of butter are about the size of wheat grains, and the butter-milk should then be drawn off.

WASHING THE BUTTER. Wash with water at the temperature which will give the butter the proper consistency for working. The temperature of the washing water will range from 50° to 58° in winter, and from 45° to 50° in summer. Some breeds of cows produce a much firmer butter than others, and the temperature of the washing water will vary on this account, as well as from other conditions, such as the period of lactation and the feed of the cows.

Washing once is sufficient where the butter is going into immediate consumption, but if it is to be held for any length of time or is intended for export, two washings are necessary.

SALTING. The object of salting is to preserve the butter and to impart to it the salt flavor. Butter salt should be fine and even in grain, easily dissolved and free from lime and other impurities. Salt will take up flavors from its surroundings ; therefore it is necessary to keep it in a clean, pure atmosphere.

The amount to be used, varies with the market to which the butter is sent. The British market demands from $\frac{3}{8}$ to $\frac{5}{8}$ of an ounce to the pound of butter, while our home market demands from $\frac{3}{4}$ to 1 ounce per pound of butter.

No special directions for salting are necessary, other than to see that the salt is evenly distributed over the mass of butter. This is specially necessary when salting in the churn ; either in the box churn or in the combined churn and worker.

When salting in the box churn, if the butter be forked or spaded over, it will usually become fairly evenly distributed ; but if the churn be revolved to mix the salt and butter, that at the ends of the churn will retain its relative position to that in the centre ; and if the centre has received more than its share of the salt, it is retained during the whole process of working. This is important to bear in mind when using the combined churn and worker.

WORKING THE BUTTER. The object of working butter is to unite the countless little granules, expel the moisture, and mix the salt evenly throughout the mass.

Salt attracts moisture, and, in dissolving, forms drops of brine, which are expelled by pressure, carrying off with them a portion of the buttermilk which still remains in the granules after washing.

Every granule of butter, however small, contains within itself more or less buttermilk. The salt having a certain action on the buttermilk thus imprisoned, aided by the kneading or working process, liberates more or less of the imprisoned buttermilk and aids its escape.

If, after a partial working, the butter can be allowed to stand for an hour or two, the more complete will be the process of distributing the now dissolved salt and the removal of surplus moisture. It is impossible to tell, on account of varying conditions, just how much working butter should have. With the Mason worker, however, we can be guided by the number of revolutions given the table; and where the butter is properly doubled at every revolution, 24 revolutions will be found sufficient for the maximum amount of working. If the butter is salted in the churn and afterwards finished on the Mason worker, less than 24 revolutions will be required to avoid mottled butter.

Combined churns and workers, also the National and Fargo workers usually have printed instructions sent with them as to the number of revolutions required for working the butter. These instructions are a guide to the operator. Overworking the butter gives it a dry, greasy appearance, while underworking or working when it is too hard, is liable to leave it streaked or mottled. In properly worked butter the granules are simply pressed firmly together, without losing their individuality; and the butter will break, when fairly firm, like cast iron; but in overworked butter the granules are crushed and kneaded into each other, making the whole a grainless mass.

PACKING. Butter, to pack properly in boxes, tubs, or pound prints, should be at a temperature of 54 degrees to 56 degrees, which gives the desired solidity for the best results in packing. Pound prints should be put up in the most attractive form, and should weigh not less than $16\frac{1}{2}$ ounces each,—the extra weight being for shrinkage before reaching the consumer. For packing in bulk, the square boxes are now almost universally used, which require lining with the heaviest quality of parchment paper. Double lining the bottom and corners of the box, having the paper cut to fold neatly and smoothly over the top of the butter is very desirable.

The parchment requires soaking in strong brine for at least 24 hours before using, as a preventive of mold, and also to prevent the paper from drawing the color from the surface of the butter.

As a further preventive of the latter, it is advisable to sprinkle a little strong brine over the finished surface of the butter before the paper is folded over the top.

Great care is necessary to have the butter firmly packed at the sides and corners of the box so that it will turn out in a solid cube.

Never use a ladle to smooth the butter over the top, as this method always leaves a greasy appearance on the surface. A straight-edge, notched to go deep enough into the butter to cut off the desired amount, makes a nice, clean finish: and with the paper folded neatly over the top, it should present a faultless appearance when opened for inspection.

BUTTER MACHINERY. In selecting machinery for the manufacture of butter, the importance of *ease of cleaning* should never be overlooked.

Pumps, churns, workers, etc., should be so constructed that all parts are easy of access.

Everything in connection with the milk, cream or butter, should be thoroughly cleaned, scalded or steamed after each operation; nooks and corners where dirt can lodge must be constantly looked after. All wooden utensils require an occasional scouring with salt. Have everything in and around the factory sweet and clean, not omitting the personal cleanliness of the butter-maker and his assistants.

CREAM-GATHERING CREAMERIES.

The principal portion of the foregoing remarks will apply equally well to the cream-gathering system. In the handling of the cream, however, this system differs materially from that of the factory separator system; and the control of the cream is left largely in the hands of the patron, which is one objectionable feature of the cream-gathering plan.

The cream being gathered only two or three times a week, is often beyond the control of the butter-maker before it is received at the creamery and the flavor has to be taken as it comes, be it good or otherwise.

Hand separators, in the near future, will play a very important part in this system of co-operative butter-making and if the cream is rightly handled from the separator it may assist very materially in improving our present methods. To do, that, our patrons *must* have ice and ice water to keep the cream in. Cream fresh from the separator must always be well cooled before being added to that in the cream can. Separators must be cleaned each time after using; and the greatest care must be taken with everything about the dairy. It should be the aim of every patron to send the cream sweet and good-flavored to the creamery; then the butter-maker will have an opportunity to apply his skill in the ripening of the cream.

Cream wagons should be provided with blankets during the hot weather. These blankets are saturated with water and thrown over the cans. This plan aids in keeping the cream cool during the journey to the creamery.

Drivers should be careful, intelligent men, with a knowledge of what constitutes good cream, and also a knowledge of how cream should be cared for by the patrons.

HAND CREAM SEPARATORS.

BY THEO. A. WIANCKO, INSTRUCTOR IN FARM DAIRY.

At the present time there is a rapidly growing demand for hand cream separators. This is especially true in districts where creameries are operated on the cream-gathering system, and in places where circumstances are such that co-operative dairying is not available. In such cases the hand separator furnishes the most satisfactory method now in vogue for getting cream from milk, and the dairyman who has a herd of from eight to twenty cows can ill afford to be without one.

In milk set for cream to rise, gravitation forces the heavier part, or milk serum, to the bottom of the vessel, while the cream, being lighter, rises more or less perfectly to the surface. With the centrifugal separator the force separating cream from milk is greatly intensified. Centrifugal force hastens the separation of the cream to such an extent that it is almost completely removed instantaneously, or in a very short space of time. The operation is purely mechanical.

Some of the advantages of the cream separator over shallow pan and cold deep-setting methods of creaming are: (1) the loss of fat in the skim-milk is reduced to a minimum (usually from .05 to .1 of one per cent.); (2) it saves the cost of utensils and the space required for their accommodation; (3) it produces a better and a more uniform quality of cream; (4) it insures purity of product; (5) it removes disease germs and enhances the keeping qualities of the butter; (6) it saves the cost and handling of ice needed to keep the milk sweet; (7) the skim-milk is in better condition for feeding purposes; and (8) the thickness of the cream can be readily regulated.

The chief objections to the separator are its first cost, and the labor of turning and washing the machine; but when we consider that the increased product made from the saving in loss of fat in skim-milk alone, over the best methods of creaming, to say nothing of its other advantages, amounts to from five to ten dollars per year for each cow, it will be seen that the separator will soon pay for itself, and will make dairy work a source of profit and satisfaction, instead of drudgery.

The cost of hand separators is from \$60 to \$125, according to size and capacity. They will cream from 160 to 450 pounds of milk per hour. Larger sizes having greater capacity are used in larger dairies, and are usually run by mechanical power. If properly cared for, a separator will last for many years. If they are turned by hand, that takes time and labor, but not nearly so much as would be taken in setting and skimming the milk, cleaning utensils, and preparing the skim-milk for feeding purposes. All except the smallest-sized hand separators are so constructed that they may be connected with a power. A light tread-power run by a large dog, or other animal, or a small gasoline engine are economical powers.

Which is the best separator at the present time, it is impossible to say, since no one separator comprises within itself all the points of merit that the ideal separator might possess. The *best* separators might be described as those best suited to the special conditions under which they are to be used. It may be that the less capable of two separators is the best, for the reason that it may have advantages and conveniences which at first sight might seem of little importance, yet be of great value in the peculiar circumstances under which it is to be used. For example, the closest skimming separator may be more difficult to operate, more inconvenient to clean, or possess other disadvantages in its mechanism less desirable than a machine which skims less closely, and these disadvantages may more than counterbalance its closer skimming power.

The points of merit which a separator should possess are: (1) Strength and simplicity of construction, (2) cheapness and durability, (3) minimum need of power with maximum capacity, (4) thoroughness or closeness of skimming, (5) strength of foundation and steadiness of motion, (6) freedom from defects in its mechanism, and (7) ease of cleaning and general conveniences of detail.

There are many kinds of hand separators now on the market, but we shall speak of them in a general way and not treat of individual machines. Before setting up a new separator a suitable place for it should be chosen, care being taken to select some clean, well ventilated place where a pure atmosphere can at all times be assured. To give a separator the necessary stability, it should be fastened to a solid floor or foundation. Care should be taken to have the top of the separator stand level in all directions, and to have it securely fastened to the floor or foundation by means of screws or bolts. A small quantity of quarter inch rubber packing placed under the outside edge of the base or under the legs before fastening improves the running of any separator.

Before the separator is started all parts should be thoroughly cleaned and all bearings well oiled and oil-cups and oil-holes free and in working condition. Special attention should be given the oil that is used. With each machine that is sent out by the makers there is sent a can of oil, of a quality that has been found by experience to answer the purpose best. Such oil can be obtained from the selling agents of the machine, and no other should be used. Two or three minutes should be taken to get the speed up to the required rate, which is stated on the crank of the machine. A small quantity of water at a temperature of from 110 to 120 degrees Fahr. should be used to warm and wet the bowl, and after speed has been acquired the flow of milk should be turned on. In turning a separator by hand we should take care to have the motion as steady as possible. The pressure on the crank should be the same all the way around.

In the use of a separator three things should be carefully watched, viz., the speed of the bowl, the temperature of the milk and the feed of the milk to the machine. With the same machine and all other conditions the same, a greater loss of butter-fat must be expected when the separator is not run up to the required speed, when the milk is below a certain temperature, or when more than a certain amount of milk is run through in a given length of time.

Milk separates best when fresh or new, and at a temperature of 90 to 100 degrees Fahr. If in any case the temperature of the milk has fallen below 85 degrees it should be heated to 90 or 100 degrees before being run into the separator to obtain the best results in close skimming. When the milk is all run through, the bowl should be flushed with warm water or a little skim-milk. The power should then be removed, and the bowl be allowed to run down of its own accord. The bowl should not be stopped by applying a brake of any kind, as it injures the bearings and shortens the life of the machine. All parts of the separator should be thoroughly washed, first in tepid water and afterwards scalded in boiling water or with steam and placed in a pure dry atmosphere after each time of using.

Nothing contributes more to success in butter-making than the care of the cream. The lower the temperature at which cream is kept previous to churning the better, on general principles, will be the results, with reference not only to the flavor of the butter but to its body as well. For this reason it is very important that the cream from a separator should always be cooled immediately after it is separated and before being added to any lot of cream previously separated. Adding fresh warm cream to that already separated and held for some time soon causes lactic fermentation, which, if not properly controlled, injures the quality of the product.

BUTTER-MAKING ON THE FARM.

BY MISS LAURA ROSE, INSTRUCTRESS IN THE FARM DAIRY DEPARTMENT.

As civilization advances, our tastes become more acute and demand finer foods. This is especially true with regard to butter. When we consider that over one-half of the butter produced in Ontario is made on the farm, should we not take pride in giving to the people a number one quality, and by so doing procure the best market price?

Bad butter invariably shows a lack of skill or care. A uniformly good butter is made only by having proper utensils and an intelligent idea of the principles which make dairying a scientific art.

THE COW. To make dairying profitable, only the best dairy cows should be kept.

Have a standard, and work your herd up to it. From 5,000 to 6,000 lbs of milk containing 3.5 per cent. butter fat is not too much to demand of a cow, if she is properly cared for and well fed.

You can judge of what a cow is doing only by occasionally weighing her milk. Keep your cows in a well-lighted, well ventilated, and comfortable stable, and give them plenty of pure water and a balanced food ration. This, with kind treatment, should bring good returns.

MILKING. Have the same person milk the same cow at the same time in the same place, and in the same order. Wipe the cow's flank and udder, and milk quickly, but gently, with clean, dry hands.

THE CREAMING OF MILK. As soon as the milk is drawn from the cow, it should be taken from the stables and strained through a fine brass wire strainer and two thicknesses of cheese cloth. Place the square of cheese cloth over the bottom of the strainer, and secure it with a tin hoop. Wash well after each time of using.

DEEP-SETTING. If the cream is raised by the deep-setting system, the cans should be placed in water the depth of the milk and the milk brought as soon as possible to 45 degrees in summer and to 40 degrees or below, but above freezing in winter. Use plenty of ice. It is economy to have ice always in the water, and just as necessary to use it in winter as in summer. A water-tight box or barrel will do as effective work as an expensive creamer.

Experiments carried on in our department this winter showed that when milk was allowed to stand 12 hours at 38 degrees, there was an average loss of .7 per cent. butter fat in the skim-milk; while at the end of 36 hours the loss was .32 per cent. butter fat. Milk should stand 24 hours in summer, and from 24 to 36 hours in winter. When this is done, richer cream is obtained and there is less loss of butter fat in the skimmilk.

A can with a tap to draw off the milk should have a bottom with a 4 or 5 inch slant. This carries away any sediment, and permits more skim-milk to be drawn off. When there is no tap use a funnel-shaped dipper with no wire around the rim, and a long, straight handle.

With a knife loosen the cream from the sides of the can, then wet the dipper in water or milk, and lower, point first, into the can, allowing the cream to flow evenly into the dipper. Repeat until all of the cream is removed. Avoid getting too much milk with the cream.

SHALLOW PANS. When ice cannot be secured, or the supply has been exhausted, or when only one or two cows are kept, then it is advisable to set the milk in shallow pans. When properly set and skimmed, as much butter fat may be recovered as in deep setting.

The chief objections to this method are: the space the pans occupy, the possibility of contamination by the large surface of milk being exposed in many cases to an impure atmosphere, the rapid souring of the milk in warm weather, and the extra labor.

Do not use the perforated skimmer. Instead, take a thin-bladed knife and loosen the cream by pressing the knife well to the sides of the pan. Lift the pan to the cream can, tilt it to allow a little of the milk to run over to wet the edge of the can; then with the aid of the knife glide the sheet of cream into the cream can. Having the pans in a room at about 60 degrees gives the best results. Avoid having a draft over the milk, as a thick, leathery coating forms on the cream because of the rapid evaporation. Skim before the milk thickens—usually at the end of 24 hours in summer and from 36 to 48 hours in winter. Tests of skim milk from shallow pans under the best conditions average about the same as skim-milk from deep setting.

DILUTION SYSTEM. Many devices have been put on the market for creaming milk by adding a certain percentage of water to the milk before setting. We have tried several, and the results have not been satisfactory. More butter fat (.8 per cent.) is lost in the skim-milk,—over twice as much as when the milk is properly set in cans or pans. There is danger of contaminating the cream by using impure water, and there is such a bulk of skim-milk to handle which is not good for household use or of very much use for stock either. Any can will answer as well as a patent dilution “separator.”

CREAM SEPARATORS A separate article in this bulletin is devoted to this method of creaming milk, otherwise much might here be said in favor of it, as it really is the ideal way of obtaining the cream; and, moreover, it pays, with eight or more cows, to have a separator.

CARE AND RIPENING OF CREAM. In the collection of cream for a churning, the cream can should stand in the coolest place in the cellar in summer, while in winter it may be kept in a room where the temperature is about 60°. Always keep the can covered and have the surroundings and atmosphere clean and sweet. Have a tin stirrer which reaches to the bottom of the can and stir thoroughly every time fresh cream is added. Each time the can is emptied, it should be thoroughly washed, scalded, and put in the sunshine for several hours. In order to be able to do this it is well to have two cream cans.

When beginning to collect cream for a fresh churning, add to your first skimming a starter or culture, which you know has a clean, good flavor.

This culture may consist of a pint or two of sour cream from your previous churning, or the same amount of good-flavored skim-milk or buttermilk. The reason for adding the culture is that the bacteria which you know produce a fine flavored butter, may take possession of the new cream before other germs which may prove objectionable gain control of it. Another method is to hold the cream sweet until twenty-four hours before churning. Then heat it to 65° and add one pint of culture for every gallon of cream. In the evening, cool to churning temperature and hold it at that over night.

To prevent loss of butter fat in the butter-milk, sweet cream should not be added during the last twelve hours before churning. Sweet cream may be

churned, but it is well to have it a few degrees lower in temperature than when sour so as to prolong the churning; otherwise there is likely to be a greater loss of butter fat in the butter-milk. Sweet cream butter lacks the pronounced pleasant aroma of ripened cream butter.

Separator cream should have the foam well stirred in, and should be cooled to 60° or 65° in winter and 55° in summer, before putting into the cream can. In winter, it is usually necessary to raise the temperature of the cream from deep setting before adding it to that previously gathered. Examine your cream, and when it has a smooth, glossy appearance, pours like molasses, and has a pleasant acid taste, it is in proper condition to churn. Have the cream lowered to churning temperature several hours before churning.

It does no injury to raise the temperature to that desired, but when the temperature of the cream is lowered just before churning, the fat globules have not had time to harden, and the result will be a soft, weak-textured butter.

With regard to pasteurization, see "Butter-making in the Creamery" in this bulletin.

CHURNING. Before using, the churn should be scalded with boiling water and then rinsed with cold water. It is better to pour the water out than let it run through the bung-hole. Floating dust will not then cling to the sides of the churn. After using, the churn should be rinsed down with hot water, thoroughly scalded with boiling water, and occasionally given a good scouring with salt. Never allow buttermilk or water to remain in the churn when not in use. Leave the plug out and the lid ajar, and keep in a cool place to prevent warping.

The ladles and butter printer should stand a few minutes in hot water, and then be put to soak in cold water.

The worker may be prepared while the butter is draining. With a fibre brush and a dipper of hot water give it a good scrubbing, and cool well with cold water. After using, or before, if necessary, scour with salt, to prevent butter from sticking to wooden utensils.

Always strain the cream into the churn through a dipper with a perforated tin bottom. In winter, add just sufficient butter-coloring of a reliable brand to give a nice yellow tint,—a teaspoonful to four gallons of cream is usually sufficient.

No definite temperature for churning can be given, but the necessity for the constant use of a thermometer must be emphasized. The quantity and richness of the cream, the breed and feed of the cows, the length of time the cows have been milking, and other conditions influence the temperature the cream should be for churning. Start with the churn about one-third full, and regulate the temperature so as to bring butter in thirty minutes. That temperature can be ascertained only from past experience. The ordinary farm cream usually contains from 18 to 20 per cent. of butter fat, and may be churned at from 54° to 60° in summer, and may vary in winter all the way from 56° to 70°. Cream containing a higher per cent. of butter fat, say 25 per cent., may be churned at a much lower temperature than poor cream. Low temperatures give a better grained butter and a more exhaustive churning.

Cream that is poor and too cold will foam. It must be taken from the churn and heated by placing the can in a pan of hot water and stirring. Poor cream often breaks but will not gather. The only remedy is to draw off part of the butter-milk, to lessen the liquid. Very rich cream is likely

to thicken in the churn so that concussion ceases. Add enough water at the same temperature as the cream, to dilute it so that it will drop. When the butter is just about gathered, add a couple of quarts of water several degrees lower than the cream. This floats the butter and allows the butter-milk to run off more freely. When the granules are the size of wheat, or when but few small specks show on the lid and sides of the churn, the butter is sufficiently gathered.

If butter comes out with first-drawn butter-milk, it is the best sign that the churning is not quite finished.

When the butter-milk is drawn, strain into the churn as much water as there was cream, or a little more. Temper the water in winter, having it from forty-eight to fifty-four degrees, according to the conditions and the mode of salting. If the butter is salted in the churn, colder water is needed than otherwise. Revolve the churn rapidly a dozen times, and wash only once. In hot weather the water may be as cold as possible.

SALTING AND WORKING. Allow the butter to drain 10 minutes before salting. Salt according to the demand of the market. Three quarters of an ounce to the pound is usually enough. If salting in the churn, use an ounce. We strongly recommend salting in the churn, as by so doing butter free from streaks can be had with the least possible amount of working; but the churn must be without dashers and the butter granules firm. The only difficulty in this method is gauging the amount of salt. Estimate the weight of butter from the last churning; then weigh the salt. To salt in the churn, tip the churn backwards and forwards once or twice, while sifting on the salt. Revolve the churn a few times to mix in the salt more evenly. After allowing it to stand fifteen minutes, slowly turn the churn to gather the butter into lumps, and allow it to stand from two to four hours. If the room be warm, it may be lifted out into a butter tub, and put into the cellar for that length of time.

For the farm dairy, there is nothing nicer than the V-shaped, lever butter-worker. It is not expensive, and is a great saver of time and strength, besides preserving the grain of the butter. Work by means of downward pressure. Avoid a sliding motion, as it makes a greasy, salvy butter. If salting on the worker, after the butter has been drained, take it from the churn, weigh and put it on the worker, weigh the salt and sift it over the butter. Work sufficiently to expel excessive moisture and thoroughly distribute the salt. If the butter is soft, work but slightly, allow it to firm, and then give it a second working.

Make into pound prints or any desired form. Have the package neat and attractive. Use parchment paper. Dip it in clear water before wrapping about the butter, to prevent sticking.

Keep the butter in a cool, clean place, and get it to market as soon as possible.

PACKED BUTTER. When the butter is to be kept for winter use, extra care should be taken to have the cream of No. 1 quality. Wash twice, salt heavier, and give two workings. Pack in well-glazed crocks to within half an inch of the top. Cover with parchment paper, and then with a layer of moistened salt. Tie down with paper and keep it in a dark, cool, clean place.

A FEW DON'TS WORTH REPEATING AND REMEMBERING.

Don't be in such a hurry that you lose money for the sake of a little time.

Don't fail to put up ice, if you use the deep-setting cans.

Don't put off churning too long. Your butter will have an old taste.

Don't fill the churn quite half full or you will wonder why you are such a long time churning.

Don't take the temperature of the cream with your finger. You cannot depend upon its accuracy.

Don't wash your milk pails, pans, can, etc., with the dish cloth. Have either a hair or fibre brush for these utensils, and give it a boiling once in a while in salt brine.

Don't dry your milk utensils. Put them in a position to drain and allow the heat from the scalding water to dry them; also give them plenty of fresh air and sunshine.

Don't live below your opportunities. Ever do your best and let that be the best that any one can do.

BULLETIN 115.

TORONTO, JULY 1901.

Ontario Agricultural College and Experimental Farm.

THE COMPARATIVE VALUES OF ONTARIO WHEATS FOR BREAD-MAKING PURPOSES.

BY R. HARCOURT, B.S.A., ASSOCIATE PROFESSOR OF CHEMISTRY.

WITH

NOTES ON VARIETIES OF WINTER WHEATS.

BY C. A. ZAVITZ, B.S.A., EXPERIMENTALIST.

During the last few years, there have been many complaints from both farmers and millers regarding the poor quality of flour that is made from Ontario-grown wheat. Farmers say that it is impossible to make as good bread from flour ground out of their wheat as they made a number of years ago. Millers declare that, where formerly the flour from home-grown wheat was in great demand, it is now a drug on the market and that they can sell only by underbidding their competitors. This deterioration in strength of flour is, no doubt, largely due to the depletion of the soil in nitrogen, and to the extensive growing of larger yielding but weaker varieties of wheat. It is undoubtedly desirable that those varieties of wheat should be grown which will give the largest returns to the grower. These may or may not be the varieties that give the greatest number of bushels per acre. It is true that at present, while some varieties are shunned by the buyer, practically the only difference made in the price is that of buying according to the weight per bushel. As the heavier wheats are usually the best, this is to some extent paying according to quality. But, beyond all this, has not the extensive growing of some of the weaker and larger-yielding varieties lowered the general price of wheat in the Province? Considerable attention has been given to the question of yields per acre; but it is almost equally important that we have definite knowledge regarding the quantity and quality of the flour the different varieties will produce; for, other things being equal, it is the quality of the flour that determines the value of the wheat.

Recognizing the importance of such information, we have during the last three years given some attention to this subject. Prior to the fall of 1900,

the work done was with varieties grown on the College farm and experimental plots. It was then thought that similar trials should be made with the same varieties of wheat grown in a number of different sections. Accordingly, letters were sent out to a number of millers in the western part of the Province, asking them to collect ten-bushel lots of the following varieties: Michigan Amber, Genesee Giant, Early Red Clawson, Dawson's Golden Chaff, and, where at all possible, the Scott and the Treadwell. In the eastern part of the Province, the Fife, White Russian, Colorado, and Thickset were asked for. The instructions were that the samples sent should be pure, true to name, and each a fair representative of the variety as grown in that particular district. In many cases, the ten-bushel samples were not taken from one load, but gathered, two bushels at a time, from different wagons as wheat was delivered at the mill. In some sections where these varieties are grown in considerable quantities, no samples were sent, because they could not be got pure, while a few were received which are not mentioned in the list. Altogether 37 ten-bushel lots were gathered, all of which were harvested in 1900 in Ontario, with the exception of one lot of Turkey Red, which was imported from Kansas.

The samples collected were ground during the latter part of November and December in a regular roller process mill, by the same millers and under as uniform conditions as possible. No attempt was made to obtain large yields of flour; for it was ground fairly high to give all the strength possible to the flour. Less than two per cent. of low grade flour was removed. Hence it was practically what is known as a "straight."

By using ten-bushel lots of wheat, and saving the flour from the last part of the run for the subsequent tests, the miller was confident that perfectly accurate samples were obtained from the different lots ground; but it was found to be impossible with small quantities of wheat to get any definite figures regarding the yield of flour in any particular case.

In the study of the quality of the flour, the figures given in the table were obtained as follows: The nitrogen was determined by the regular Gunning method and multiplied by 6.25 to give proteids, or flesh-forming constituents, of the flour, fully 90 per cent. of which is gluten. The gluten was obtained by doughing up ten grams of flour and allowing it to stand for one hour, when it was washed in a small stream of water over a fine copper sieve until free from starch, care being taken to recover all the gluten. It was then dried as much as possible in the hand and weighed as "wet gluten," after which it was dried to constant weight in a water oven and weighed as "dry gluten." The per cent. of "water absorption" was determined by taking a definite weight of flour and measuring the amount of water required to make a dough of a standard consistency. The figures represent the per cent. of water the flour will absorb. In the determination of the yield of bread, principally ten and fifteen pound lots of flour were baked independently by two of the most experienced bakers in Guelph. When their results did not agree closely, a third trial was made. The bread was then scored on the basis of 100 points for ideal bread.

The results of this work will be found in the following table, where the different lots of wheat tested are arranged according to the variety.

TABLE SHOWING QUALITY OF FLOUR.

Fall Varieties.	Wheat.		Flour.					
	Locality Where Grown.	Weight per Measured Bushel.	Proteids, N. x 6.25 Per cent.	Crude Gluten.		Water Absorp- tion. Per cent.	Yield of Bread per 100 lbs. Flour.	Quality of Bread 100 as Standard.
				Wet. Per cent.	Dry. Per cent.			
1. Turkey Red	Waterloo....	63.0	10.80	40.68	12.60	63.0	158.5	95
2. " "	"	63.0	10.73	39.09	12.12	62.5	157.7	95
3. " "	Kansas.....	62.5	10.80	40.60	12.33	62.5	156.8	95
4. Michigan Amber	Guelph.....	64.0	10.56	35.62	12.92	61.5	151.0	90
5. " "	Clinton	63.0	9.39	33.95	11.62	60.0	145.5	90
6. " "	Newmarket ..	61.0	9.45	32.32	10.93	60.0	146.5	88
7. " "	Guelph.....	62.7	10.46	33.28	11.20	60.0	149.9	85
8. " "	Chatham....	60.0	9.64	33.57	11.43	59.0	146.6	90
9. Genesee Giant.....	Guelph.....	62.5	9.89	34.94	10.92	60.0	148.0	85
10. " "	Clinton	62.0	9.47	33.63	11.57	59.0	143.8	84
11. " "	Tavistock ..	62.0	10.34	33.88	11.09	60.0	148.2	84
12. " "	Guelph.....	61.0	9.30	32.65	11.20	60.0	146.6	80
13. " "	Chatham....	60.5	9.67	33.93	11.28	60.0	150.7	90
14. Dawson's Golden Chaff ..	Guelph.....	60.0	9.30	28.51	9.55	57.0	140.4	80
15. " " "	Clinton	60.7	9.24	28.95	10.64	57.0	139.4	85
16. " " "	Tavistock ..	60.0	9.73	30.31	11.23	57.0	141.2	82
17. " " "	Guelph	60.0	8.74	28.66	10.85	57.0	141.1	75
18. " " "	St. Thomas..	59.5	8.86	30.03	10.37	58.0	144.8	90
19. " " "	Guelph	60.0	8.64	28.27	10.58	56.5	139.7	80
20. " " "	Chatham....	59.5	9.79	30.24	10.55	58.0	144.5	80
21. Early Red Clawson	Guelph.....	61.0	8.68	24.25	9.08	56.0	141.9	75
22. " "	Clinton	59.0	8.26	26.39	9.30	57.0	143.0	75
23. " "	Guelph	60.0	9.49	30.48	11.22	58.0	144.7	75
24. Manchester	St. Thomas..	61.0	10.42	31.13	11.00	58.0	144.5	85
25. Scott	Clinton	63.5	10.18	36.63	12.49	60.0	148.2	90
26. Walker's Reliance	Tavistock ..	62.0	10.07	32.14	11.58	59.0	145.7	80
27. Jones' Winter Life.....	Newmarket..	61.0	9.38	31.69	11.09	60.0	146.1	85
28. Diamond Grit.....	Guelph.....	64.0	9.43	29.85	10.62	59.0	145.1	75
Spring Varieties.								
29. Fife	Bowmanville.	61.0	11.92	43.35	13.98	60.0	154.2	100
30. Herison Bearded.....	Bowmanville.	63.0	9.44	28.58	10.13	57.0	140.5	80
31. White Russian.....	Bowmanville.	60.0	10.27	36.60	12.38	58.0	146.5	85
32. " "	Lindsay	61.0	9.48	34.56	11.95	58.0	143.3	82
33. " "	Beaverton ..	61.0	9.21	31.30	11.13	59.0	147.0	82
34. Thickset.....	Lindsay	63.0	10.19	29.01	10.72	57.5	140.3	80
35. " "	Bowmanville.	62.0	9.24	31.07	10.48	57.5	141.0	75
36. Colorado.....	Lindsay	62.5	9.36	33.13	11.18	57.0	140.0	75
37. " "	Bowmanville.	60.0	9.29	30.26	10.53	57.0	140.1	75

HEAVY VERSUS LIGHT WHEAT. It will be noticed that the heavier the wheat per measured bushel, the better the quality of the flour. Yet there are some marked exceptions, as in Nos. 22, 28, and 34. A heavy wheat usually contains a high percent of nitrogenous matter, and has a dark, gluey, translucent appearance, which becomes more apparent when the kernel is cut through. Such a wheat contains a large proportion of gluten of a good quality. A light wheat, that is, light weight per measured bushel, usually has a characteristic "weak" color, and a cross section of the grain presents a white, starchy appearance, and lacks the glueyness which is seen in a "strong" wheat. Of course, same varieties are naturally heavier and "stronger" than others; but soil and season have a very marked influence on the weight per bushel, and also on the quality of the flour that can be made from any given variety.

GLUTEN. It is gluten which gives strength to flour. Many are familiar with it in the form of gum made by chewing wheat. It is of an elastic nature, capable of being strung out very thin. In the baking of bread, the gases, formed through the action of yeast, in rising up through the dough, come in contact with this elastic substance, which spreads out and retains the gases in small cavities, thus causing the bread to rise. Other things being equal, the more gluten there is in flour, the better the bread rises and the larger the yield. The preceding table shows that the amount of water absorbed by a flour varies somewhat with the percent of gluten, yet there are indications that quality in gluten is a factor as well as quantity. Some glutens are firm and elastic, others are soft and sticky; the former absorb more water than the latter, and consequently give a larger yield of bread. In the table, quality of gluten is indicated by the difference between the wet and dry gluten. The gluten of Turkey Red wheat is of better quality than that of the Michigan Amber, and the Dawson's Golden Chaff better than Early Red Clawson.

YIELD AND QUALITY OF BREAD The final test of the quality of the different flours is the yield and quality of bread they produce. For the sake of clearer comparison on this point, the average yield of bread from one hundred pounds of flour and the average quality, as indicated by the number of points given to each, have been placed in the following table:

<i>Fall Wheats.</i>	Yield of Bread per 100 lbs. of flour.	Average qua- lity possible, 100.
Turkey Red	157.6	95
*Scott	148.2	90
Michigan Amber	147.9	88.6
Genesee Giant	147.4	84
*Jones' Winter Fife	146.1	85
*Walker's Reliable	145.7	80
*Diamond Grit	145.1	75
*Manchester	144.5	85
Early Red Clawson	143.2	75
Dawson's Golden Chaff	141.6	81.1
<i>Spring Wheats.</i>		
*Fife	154.2	100
White Russian	145.6	82.3
Thicket	140.6	77.5
*Herison Bearded	140.5	80
Colorado	140.1	75

* Only one lot of wheat was ground.

The Turkey Red gave the largest yield of bread; that from the Fife was, however, superior in quality, it being the only one among all the varieties which received the maximum number of marks for quality. The Turkey Red made a well-raised loaf, the crumb of which was flaky and had a rich creamy color; the crust was soft and thin and had the glossy, brown appearance that is so much desired in a good loaf of bread. It was a little inferior to the Fife in texture. Both the crust and the crumb of the bread from the Genesee Giant were very light in color; otherwise the bread was good. The Dawson's Golden Chaff gave 16 lbs. less bread from a hundredweight of flour than the Turkey Red, the lowest yield among the fall wheats, but it was not the lowest in quality. It rose fairly well in the pan and the crust was good, but the crumb was somewhat open in texture and dark in color. The flour

from Early Red Clawson wheat made a decidedly inferior loaf in every respect. It did not rise well and lacked color in both crust and crumb. In the latter respect it resembled the Genesee Giant; the crust, however, was thicker and much harder and always broke across the top during the baking. The Diamond Grit, Colorado, and Thickset all made bread which was very thick in the crust and coarse-grained.

QUALITY AFFECTED BY BAKING. A marked difference was apparent in the fermentation in the various doughs. Some "worked" much faster than others; and if not taken at the proper time for the different steps in the process of bread-making, a poor loaf of bread was invariably the result. One of the fastest, if not the fastest, working flour among those tested was the Dawson's Golden Chaff. It was found that with care a good loaf of bread could be made from this flour; but if abused in any way, it always yielded a flat, coarse-grained, dark-colored loaf. To bring out this point more clearly, a strong and a weak flour, Turkey Red and Dawson's Golden Chaff, were baked separately, every possible condition favorable to the production of a good loaf of bread having been given in each case. Second lots of the same flours were then treated with the same fermentation and given the same amount of work, but less care was taken in the details of the work. For instance, the temperature of the liquor used in making the dough was a few degrees higher, and the dough was allowed to stand a little too long in the pans before being put into the oven. The result was that the bread from the strong flour was equally good with the two different treatments, while with the weak flour good bread was got in one case, and a poor, coarse, dark loaf in the other.

There is, no doubt, much truth in the old saying that "anybody can make good bread from a strong flour, but that it takes a skilful baker to make good bread from a weak flour." To get the best results, it is essential that the baker understand the nature of the flour he has to deal with. During the fermentation process, the dough made from a strong flour will rise up and "drop" and rise again a second and even a third time, whereas, the dough from a weak flour, if allowed to "drop" once, will not rise again. It must, therefore, have more careful attention throughout the whole of the bread-making process. It is, no doubt, true that some flour is spoiled during the process of manufacture, and by the length of time and the manner in which it has been kept; but it is equally true that many flours are spoiled in the baking, because the baker does not understand the peculiarities of the particular flour on hand.

INFLUENCE OF ENVIRONMENT. Mention has been made of the fact that wheat is very susceptible to changes according to its environment. The inherent tendency to change which is found in all grains, is most marked in wheat. A variety may be improved by selection and by modifying such conditions of environment as it is in the power of man to influence; or, through want of care, it may deteriorate very rapidly.

In a recent article, Prof. Snyder of Minnesota Agricultural College, likens the development of a wheat kernel to the fattening of an ox. The proteids of wheat, the greater part of which is made up of the constituents which make gluten, form the frame-work of the grain, just as the proteids of the animal form its bone and muscle. The animal form is rounded out with fat, while the grain becomes plump through the taking up of starch. But while the animal obtains all its food from without itself, the grain

must get its supply from the plant of which it is a part. The ripening grain cannot obtain that which is not in the plant; and, further, anything that hinders the transferring of the food from the plant to the grain must affect its ultimate composition. Consequently soil, climate, and season have a marked effect on both the quantity and quality of the grain.

SEASON. In the growing of wheat, the greatest difficulty to contend with is the frequency of unfavorable climatic conditions. In Prof. Blount's study of the wheats of Colorado, he draws attention to a case where the quality of a crop of wheat was so injured by a storm during the ripening period that it took two years to recover its former strength for flour purposes.* In Ontario, the season of 1898 was very unfavorable for the production of good strong wheat. Wheat examined that year, which was grown in the neighborhood of Guelph, gave but two-thirds as much gluten as the same variety grown on the same soil in 1900. The past season was an exceptionally good one for the proper maturing and harvesting of wheat in Ontario, while in Manitoba the reverse was true. As a result, some Ontario winter wheats are this year making flour fully as strong as that from wheat grown in Manitoba. Indeed, in some cases "patent" fall wheat flour is being used this year to strengthen the Manitoba spring wheat flour.

SOIL AND MANURE. The influence of soil upon the quality of wheat is not so marked as that of season. Sir J. B. Lawes and J. H. Gilbert, as a result of their extensive work in wheat at Rothamsted,† point out that manure had not so great an influence as season, which is explained by the fact that favorable or unfavorable seed forming and ripening may overcome the effect of a luxuriant growth. A strong soil tends to produce a strong wheat, and it is no doubt due to this fact that the newer lands of the West produce better wheat than the older and more exhausted lands of the East.

LOCALITY. As regards locality, it is no doubt true that "cereals attain their best development at their northern limit of production"; but this principle depends on the amount of sunshine and the nature of the soil on which it grows. All localities having widely different climates, soils or other conditions, produce their peculiar varieties and modify those brought to them. It must be remembered, however, that on ordinary soils and with only average care in the selection of seed, the tendency is for the wheat to deteriorate rather than to improve.

CHANGE OF SEED. Because of these inherent tendencies of wheat to change it becomes absolutely necessary, if improvement in quality is to be looked for or even maintained, to exercise the greatest care in the selection of seed. Experience has shown that wherever a crop has been weakened in its growth, or injured in the ripening or harvesting process, the grain is poorer in quality; and seed selected from such grain, even with the most favorable conditions, may not regain its former quality in one year. The grain which is to be used for seed should be selected from the most thrifty-growing parts of the field, before the crop is harvested, when all the conditions of its growth and ripening are known. A change of seed from some locality where, either through greater care or more favorable conditions, the variety desired has been able to hold its own, should be made every few years; but here, also, attention must be paid to the previous history of the grain, if the best results are to be obtained.

* Bulletin No. 1, Division of Chemistry, Department of Agriculture, Washington, U.S.A.

† Journal of the Chemical Society, Volume XLV., August, 1884.

VARIETIES OF WINTER WHEAT.

C. A. ZAVITZ, B.S.A., EXPERIMENTALIST.

It is very important that winter wheat growers take every available means to secure those varieties which are likely to give the best results. By experiments conducted within the past thirteen years at the Ontario Agricultural College with 159 varieties of winter wheat, it has been found that there is a great variation in the comparative results obtained from the different varieties. The kinds which have been grown include practically all of the Canadian varieties, as well as many imported from Russia, Germany, France, England, Scotland, Australia, and the United States. Ninety-four kinds have been tested for five years or over; and this bulletin gives the average of the five years' results from the growing of forty of the most promising varieties included in the test.

All varieties have been tested under as nearly similar conditions as to kind of soil, method of cultivation, time of seeding, etc., as it has been possible to secure. The conditions of the experiment would naturally vary from year to year, as, for instance, within the five years the wheats have been grown on high land, and on land of medium elevation. In every instance, the plots are situated side by side and are separated from one another by paths three feet wide. No commercial fertilizers have been used at any time in the experiment. The seed was sown broadcast, at the rate of two bushels per acre, and usually about the first of September. The crops were carefully cradled, and when properly dried were threshed with a small-sized grain separator specially adapted to the work.

From the following table it will be seen that there are twenty varieties with bearded and twenty with beardless heads. The average results for each of these classes are as follows:

	Bearded. (20 Varieties.)	Beardless. (20 Varieties.)
Average height (inches).....	46.2	47.1
Per cent. of crop lodged.....	34.4	28.2
Per cent. of rust	14.9	18.0
Comparative hardness of grain	80.0	76.0
Weight of grain per measured bu. (lbs.)	61.2	60.7
Bushels per acre	45.7	45.8

Of the forty varieties here reported, thirty-two varieties have grain which is classed as red or amber, and only eight have white grain. The average results of the two classes are represented by the following figures:

	Red Wheat. (32 Varieties.)	White Wheat. (8 Varieties.)
Average height (inches).....	46.5	47.3
Per cent. of crop lodged.....	34.1	19.9
Per cent. of rust	15.3	20.8
Comparative hardness of grain	80.0	69.8
Weight of grain per measured bu. (lbs.)	61.2	59.8
Bushels per acre	46.1	44.5

Several of the varieties here reported have been used for co-operative experiments throughout Ontario. These experiments have been successfully conducted on about eight hundred farms within the past five years. It is found that the varieties which have given good average results in the experiments conducted at the College for a few years in succession, have usually given good results throughout the Province. In the distribution we have sent out, not only the varieties which have produced the best results in yield, strength of straw, etc., but also those varieties which possess the best milling qualities.

Results from growing Forty Varieties of Winter Wheat for Five Years.

Varieties.	Bearded or Bald.	Grain White or Red.	Date of maturity.	Average height.	Per cent. of crop lodged.	Per cent. of rust.	Comparative hardness of grain for two years.	Weight per bushel.	Straw per acre.	Grain per acre.
			July	inches				lbs.	tons	bus.
1. Dawson's Golden Chaff	Ba	W	18	46	16	23	64	60.1	3.2	55.0
2. Imperial Amber	Be	R	18	48	35	11	76	60.9	3.5	53.8
3. Egyptian Amber	Be	R	19	47	39	13	73	61.3	3.5	52.3
4. Michigan Amber	Be	R	18	46	34	14	76	60.9	3.2	51.6
5. Early Genesee Giant	Be	W	19	48	17	28	72	60.4	3.3	50.9
6. Golden Drop	Ba	R	17	47	28	23	69	61.4	3.0	50.6
7. Reliable	Be	R	20	48	42	11	71	61.2	3.5	50.6
8. Early Red Clawson	Ba	R	18	46	30	26	69	59.6	2.9	50.1
9. Russian Amber	Be	R	19	46	37	12	75	61.6	3.3	50.1
10. Poole	Ba	R	18	46	28	13	73	61.3	3.0	49.1
11. Tasmania Red	Be	R	19	45	54	13	84	61.7	3.1	47.5
12. Emporium	Ba	R	19	49	29	10	84	61.0	3.4	47.3
13. Tuscan Island	Be	R	18	48	39	21	86	61.5	3.0	47.1
14. Red Velvet Chaff	Ba	R	18	48	27	26	84	59.5	3.1	46.8
15. Rudy	Be	R	16	46	42	17	81	61.5	2.7	46.8
16. Zimmerman	Ba	R	18	47	31	12	80	61.4	2.9	46.7
17. American Bronze	Ba	R	20	49	5	32	72	60.4	2.9	46.6
18. Geneva	Be	R	17	45	21	9	82	63.1	3.0	46.3
19. Stewart's Champion	Ba	R	20	50	21	19	79	59.7	3.1	46.2
20. Arnold's Hybrid	Ba	R	17	46	27	11	75	62.2	2.9	46.1
21. Early Ripe	Ba	R	18	47	34	15	80	61.4	3.1	45.5
22. Bissell	Be	R	17	44	45	8	80	62.3	2.8	45.4
23. Pride of Genesee	Be	R	19	49	38	13	92	61.3	2.8	45.4
24. Red May	Ba	R	16	46	30	11	74	62.7	2.9	45.4
25. Siberian	Ba	R	19	48	42	12	79	62.0	3.0	45.2
26. Bulgarian	Be	W	20	49	21	16	70	60.6	2.9	44.5
27. Pride of Illinois	Ba	R	18	47	47	19	75	60.7	2.9	44.2
28. McPherson	Ba	R	16	46	23	11	86	62.7	2.8	43.7
29. German Emperor	Ba	R	20	47	54	14	83	59.6	3.2	43.4
30. Standard	Ba	W	20	46	21	21	70	59.1	2.8	43.2
31. Kentucky Giant	Be	R	20	47	32	13	87	61.2	2.8	41.9
32. New Columbia	Ba	R	17	45	18	13	80	60.4	2.8	41.2
33. Treadwell	Be	W	19	48	13	14	68	60.6	2.5	41.1
34. Nonpareil	Be	W	20	45	19	15	71	59.6	2.3	41.0
35. Velvet Chaff	Be	R	17	44	16	19	83	62.3	2.4	40.8
36. Turkey Red	Be	R	16	42	45	9	100	61.8	2.4	40.3
37. Soules	Ba	W	19	47	18	20	68	58.7	2.6	40.2
38. Silver Star	Ba	W	23	49	34	29	75	59.4	2.7	40.1
39. Amherst Isle	Be	R	21	40	64	10	94	60.0	2.1	39.3
40. Helena	Be	R	20	49	34	31	78	59.5	2.8	36.3

In another part of this bulletin, Prof. Harcourt has reported on the comparative value of the flour for bread-making of a few of the prominent varieties included in the list. The samples used came principally from five Ontario counties from which we have obtained one hundred and fifty reports of successfully conducted experiments within a period of five years. The results of the co-operative experiments show the average yield of grain per acre from each of these counties to be as follows :

Perth, 36.2 bushels; York, 33.0 bushels; Kent, 31.3 bushels; Elgin, 30.9 bushels; Huron, 28.6 bushels.

Ontario Agricultural College and Experimental Farm.

[PUBLISHED BY THE ONTARIO DEPARTMENT OF AGRICULTURE, TORONTO.]

THE HESSIAN FLY IN ONTARIO.

BY WM. LOCHHEAD, M.A., M.S., PROFESSOR OF BIOLOGY AND GEOLOGY,
ONTARIO AGRICULTURE COLLEGE, GUELPH.

The Hessian-fly is not a new pest in Canada. A search among the records shows that it was present in 1805, 1816, 1846 1857, and from 1877-1884. In the early fifties, along with the wheat midge, it caused an almost complete failure of the wheat crop in Ontario and Quebec. In 1856, the Government offered prizes of £40, £25, and £15 for the best essays on "The Origin, Nature, and Habits, and the History of the Progress from Time to Time, and the Causes of the Progress of the Weevil, Hessian Fly, Midge, and such Other Insects as have made Ravages on the Wheat Crops in Canada, and on Such Diseases as the Wheat Crops have been subjected to, and on the Best Means of evading or guarding against them." The first-prize essay, prepared by Prof. Hinde, of Toronto, was printed by the Government, and largely distributed in the country sections. The ravages of the Hessian Fly about 1878 were felt over the larger portion of the Province of Ontario, and in some sections the growing of wheat was discontinued for two or three years.

The recent outbreak dates from 1899. In that year, the south-western counties suffered to some extent; but the amount of damage done in each of the past two seasons far exceeds that in 1899. All counties south of the main-line of the Grand Trunk Railway running from Toronto to Sarnia are badly infested. Over this large area, the infestation is greatest in the counties bordering on Lake Erie and in the valley of the Thames, where the fall wheat is almost a total failure.

The Hessian Fly is generally supposed to have been introduced into America by the Hessian soldiers during the Revolutionary War. There is no trace of its presence on this continent prior to 1778, when it was noticed at New York. It may be safely inferred that as its food plants, wheat, barley, and rye were introduced from the East, the native home of the Hessian Fly was also in the East, probably Western Asia. At present the Fly is widely distributed through North America and Europe.

LOSSES BY THE HESSIAN FLY IN ONTARIO.

The average production of wheat in Ontario during the past five years has exceeded 25,000,000 bushels per year, with a value not less than \$16,000,000. On the supposition that the infested area ordinarily produces one-fifth of the total yield of wheat in the Province, and that the ravages of the Hessian Fly during 1901 in the same area have destroyed fully two-thirds of the average crop, then it must be conceded that the actual money lost exceeds \$2,000,000. To this loss must be added the loss of barley and rye crops caused by the same pest. This is no small amount; for the average production of these crops in Ontario during the last five years has not been much below a total of 20,000,000 bushels, worth in round numbers \$10,000,000. It is probable, then, that the total loss caused by the Hessian Fly in the Province of Ontario in 1901 will not fall below \$2,500,000.

DESCRIPTION.

Thomas Say, an American, published the first description of the fly in 1817, and gave it the scientific name of *Cecidomyia destructor*.



Fig. 1. —A, male Hessian Fly, much enlarged ; B, female, also much enlarged ; C, egg ; D, maggot ; E, flaxseed stage ; F, piece of stalk showing fly, natural size, laying eggs ; G, stalk of wheat injured at a, by the fly. The fine lines beside C, D, and E show the true length of these stages, the drawings being enlarged. (Modified from Riley.)

(Bulletin 46, Penn. Dept. of Agriculture, Harrisburg, Pa., by Dr. H. T. Fernald.)

There are four distinct stages in each generation of this insect, viz., the egg, the larva or maggot, the pupa, and the adult. 1. The adult insect is a

small two-winged fly, about half the size of the common mosquito, which it closely resembles. (Fig. 1). The female is larger than the male, being about one-tenth of an inch long, and dark in color. The legs are quite long, and the wings smoky black. 2. The eggs are one-fiftieth of an inch in length, spindle-shaped, and reddish. 3. The maggot or larva passes through three distinct stages during its development. During the first stage, it travels from the egg from which it hatches, down the leaf to the next joint. During the second stage it is fixed to the stalk, where it feeds on the juices of the plant. When full grown the maggot of this stage is about one-eighth of an inch in length and of a transparent, white color. The third stage is passed in the so-called "flax-seed" state formed by the cast-off skin of the second stage. In this stage the insect is harmless. The critical periods of the insect's life, viz, the hot, dry summer and the cold winter, are passed in the flax-seed condition. The maggot of the "flax-seed" has a peculiar "breast bone" (Fig. 2), the function of



Fig. 2.—Different stages in the life of the Hessian Fly : a, female fly ; c, larva or maggot ; e, pupa formed inside the "flaxseed" ; f, puparium or "flaxseed" ; g, infested wheat stem, showing emergence of pupae and adults ; all much enlarged ; the hair-lines beside the figures indicating their natural size. (Adapted from Marlatt.)

which is probably to enable the maggot to reverse its position ; for up to this time, it has been resting, head downward ; but now it turns around and rests, head upward. 4. The pupa is rosy-colored and has a pointed beak, by means of which it cuts open the pupa case when it emerges as an adult or full-fledged two-winged fly.

LIFE HISTORY.

In the Peninsula of Ontario, there are two generations, or broods, each year. Commencing with the fall brood, we find that the adult female deposits from a few to thirty or more eggs on the upper surface of the leaf of the young wheat plant which has just emerged from the ground. In ordinary seasons, if there has been rain in the second or third week in August, egg-laying is

done the last week of August and the first week of September ; but weather conditions may retard the escape of the "flax-seeds," so that egg-laying may take place almost two weeks after the normal period. Such conditions occurred the last two seasons, when drouth prevailed throughout the month of August, and mild weather continued long into the fall. The result was the deposition of eggs as late as the 20th of September, a date nearly two weeks later than usual.

The eggs hatch in about four days after they are deposited, and the maggots forthwith begin to move down the leaf and stem within the leaf sheath, to the base of the plant in the case of the fall brood, but to the first joint above the ground, in the case of the spring brood. The maggot soon becomes fixed or imbedded in the stem, where it remains for about three weeks before changing into the "flax-seed" stage. In Ontario this stage is entered upon usually about the end of September, in which condition it remains all winter and early spring. About the 1st of May, it becomes a pupa, but soon the fly emerges to lay the eggs of the spring brood. (Fig. 2, g). The maggots of the spring brood are usually all in the flax-seed stage by the 10th or 15th of June, in which condition they remain until about the end of August. (Fig. 3).

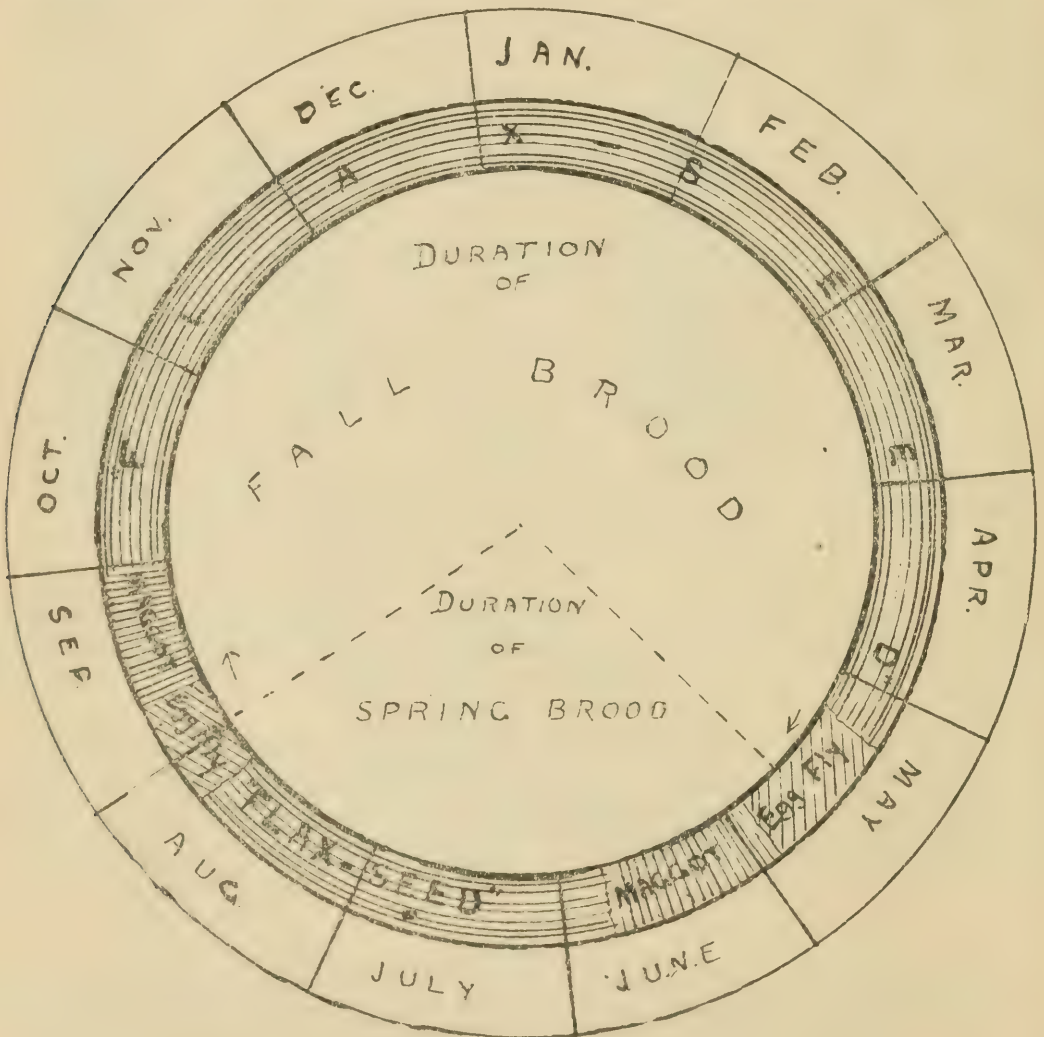


Fig. 3.—Diagram showing the life-history of the Hessian Fly and the duration of the two broods. (Original.)



Fig. 4.

Unaffected Wheat Plant. Youngest leaf as it unfolds and pushes upward is tubular and spindle-shaped. (After Webster).



Fig. 5.

Affected Wheat Plant. Spindle-shaped central shoot having been destroyed is absent; leaves are broader, darker green, more vertical and bunchy. (After Webster).

The life-time of the adult fly is short, lasting only the few days necessary for the deposition of the eggs. If mating occurs promptly, the life of the fly may not be longer than a few hours. A knowledge of this fact is of some importance; for within a few days after the adults are seen in any large numbers, it may be considered safe to sow wheat.

The following observations of the spring brood were made at Guelph:

Adult flies in large numbers on May 10th and 11th;

Eggs seen on the leaves of wheat plants from May 15th to 20th;

Maggots first seen at first joint above the ground the last days in May;

All the maggots in the "flax seed" stage by June 20th.

In the southern wheat districts, there are *supplemental* broods of the Hessian Fly, one following the usual spring brood and another preceding the usual fall brood. As a rule, however, these supplemental broods are unimportant in our northern wheat districts, but under abnormal conditions they may become somewhat troublesome and difficult to treat. It is very probable that it is through these supplemental broods that the pest manages to persist in most of the wheat growing districts, in spite of the destruction of the spring and fall broods.

When wheat is attacked in the fall, close observers notice that the leaves are darker green in color for a while, due no doubt to the stimulus given by the maggot to the tissues while embedding itself in the stalk, causing a broadening of some of the leaves and a deeper green. Soon, however, the plants begin to assume a brown tinge, followed by a yellowish color, indicating the death of the stalks and leaves affected.

The appearance of plants attacked by the spring brood is quite characteristic. As the flax-seeds are usually situated just above the first joint next the ground, the stalks bend abruptly at the point attacked, and near harvest time they are usually broken off. The heads are small, the grain is small or shrunken, and the crop is scarcely worth harvesting.

ENEMIES OF THE HESSIAN FLY.

In my studies of the Hessian Fly this year, I made an effort to determine the number of parasitic insects which were preying upon the pest, but unfortunately very few could be found. This scarcity of parasites,



Fig. 6.—*Merisus destructor* (from Riley).
The hair-lines beside each figure indicate the actual size of the insects.

it seems to me, is rather startling, for it means that there will be no material reduction in the numbers of the Hessian Fly for the coming season. It may be that the hundred or more samples of affected wheat stems procured from different parts of the infested area, were not fair samples, as not more than two per cent. of the "flax-seeds" under my observation were parasitized. This is a small percentage, when we take into account the fact that the Hessian Fly has been very abundant for two years. In ordinary outbreaks, two

years are usually sufficient time for parasites to develop in large numbers. The forms identified were *Merisus destructor* (Fig. 6), and *Eupelmus allynii* (Fig. 7).

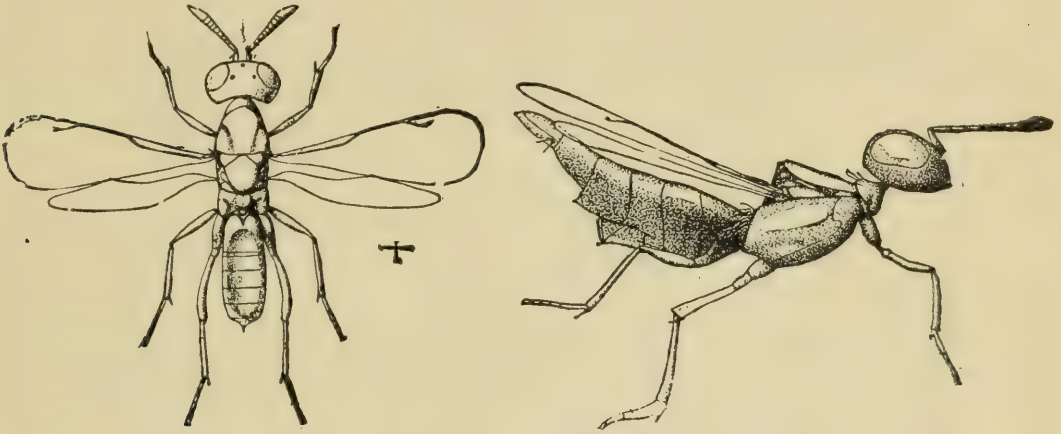


Fig. 7.—*Eupelmus allynii*, male (after Riley). *Eupelmus allynii*, female (from Riley).

However valuable parasites may be in limiting the numbers of the Hessian Fly, and however effective and useful they may be where other preventives are neglected, they can never take the place of active measures, if perfect immunity is desired. A prominent authority states that "but for its natural enemies the Hessian Fly would render it impossible to grow wheat successfully in many sections of the United States."

INSECTS SOMETIMES MISTAKEN FOR THE HESSIAN FLY.

The following insects are frequently mistaken for the Hessian Fly:

American Frit Fly (*Oscinis carbonaria*), Wheat Stem Maggot or Wheat Bulb-Worm (*Meromyza Americana*) (Fig. 8), and Wheat Midge (*Diplosis tritici*) (Fig. 9). Although these are quite unlike in appearance, yet many wheat growers are unable to identify them with any degree of certainty. In order that correspondents may be the better able to name the common wheat pests, a table of characteristic differences between the forms, sufficient for identification purposes, is here given. I am much indebted for the chief characteristics of the forms described to the valuable reports of Dr. Fletcher, of the Dominion Experimental Farm, Ottawa.

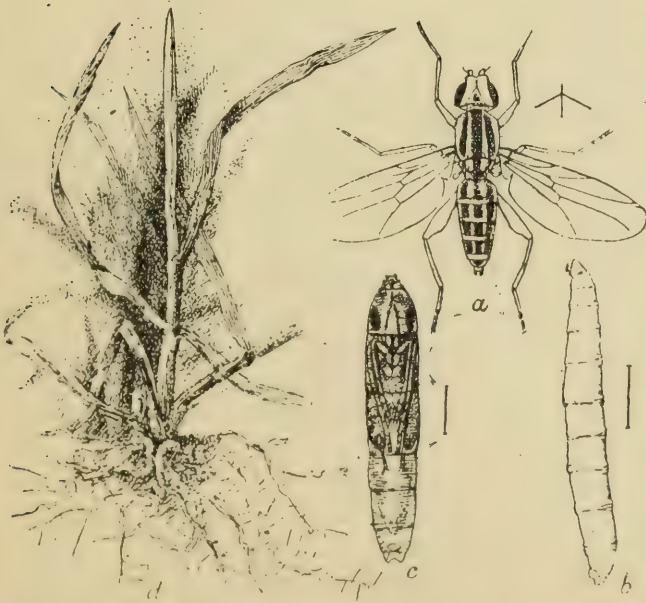


Fig. 8.—Wheat bulb-worm (*Meromyza Americana*): a, mature fly; b, larva; c, puparium; d, infested wheat stem—all enlarged except d (Marlatt).

FOUR INSECT ENEMIES OF GROWING WHEAT.

Name of Insect.	Maggot Stage.	Pupal Stage.	Adult Stage.	Effect on Crop.
American Frit Fly..	Maggot long and slender, yellowish white, with two small but distinct hook-like jaws, and two little knob-like processes on the last segment of body. Length 1-12th of an inch.	Pupa-case, cigar-shaped, and pale chestnut brown.	Colors, black and yellowish white. A small insect not more than one-fifteenth of an inch in length.	Centre of young shoot destroyed at the ground in the autumn.
Wheat-Stem Maggot or Wheat Bulb-Worm	In shape and structure, like that of Frit-Fly, but is of a clear glassy, green color; also much larger, one-quarter of an inch long when full grown. (Fig. 8, b.)	Pupa-case, translucent pale green. (Fig. 8, c.)	Fly is slender, yellowish green, one-fifth of an inch long, with three dark lines extending down the back. Eyes, golden green. (Fig. 8, a.)	In autumn central portion of stem cut off, causing central blade to discolor and die. In summer produces the silver tops or "white heads;" greenish maggots in stem just above top joint.
Wheat Midge	Maggot short, oval in shape, one-twelfth of an inch long when full grown; color, orange yellow. (Fig. 9, c.)	Pupa-cases, small, in the ground, about the size of a mustard seed.	A minute fly, one-tenth of an inch in length, color varying from orange to yellow, but smoky-tinged on the back above the wings. (Fig. 9, a, b)	The orange colored maggots feeding on the grains in the young heads, causing them to shrivel and to fill imperfectly.
Hessian Fly	Maggot proportionately much broader than those of Frit-Fly and Wheat-Stem Maggot; clear white, and nearly always shows a green stripe down the middle. The larva within the flax-seed has a horny-forked organ called the "breast bone" Length one-eighth of an inch when full grown. (Figs. 1, d, and 2, c.)	Pupa-cases, deep rich brown, like small flax-seeds. (Figs. 1, e, and 2, f.)	A delicate, dusky fly, one-eighth of an inch in length, and about half the size of a mosquito. (Figs 1, a, b, and 2, e.)	In autumn the young wheat plants become brown and yellow. Whitish maggots and flax-seeds imbedded in the stem at the crown of the root. In summer the maggots and flax-seeds are usually found at first or second joint from the ground. Injured stalks often bend over.

THE FOOD PLANTS OF THE HESSIAN FLY.

Wheat, rye, and barley have for a long time been recognized as the distinctive food plants of the Hessian Fly; but it has been asserted recently, by some observers, that it can live on certain grasses, viz., timothy, couch-grass,

wild rye grass, and a species of chess. It is, however, generally conceded that the insect found on these grasses is not the Hessian Fly but a closely related species.

While precise experimental evidence in every case may be desirable, we have the general fact that throughout an immense territory in the United States where wheat is grown in close proximity to oats, timothy, and other grasses, we have never had a record of the Hessian Fly's attack upon these crops. In view of this fact we may safely conclude that *Wheat, rye, and barley are the normal and only food plants of this insect.*

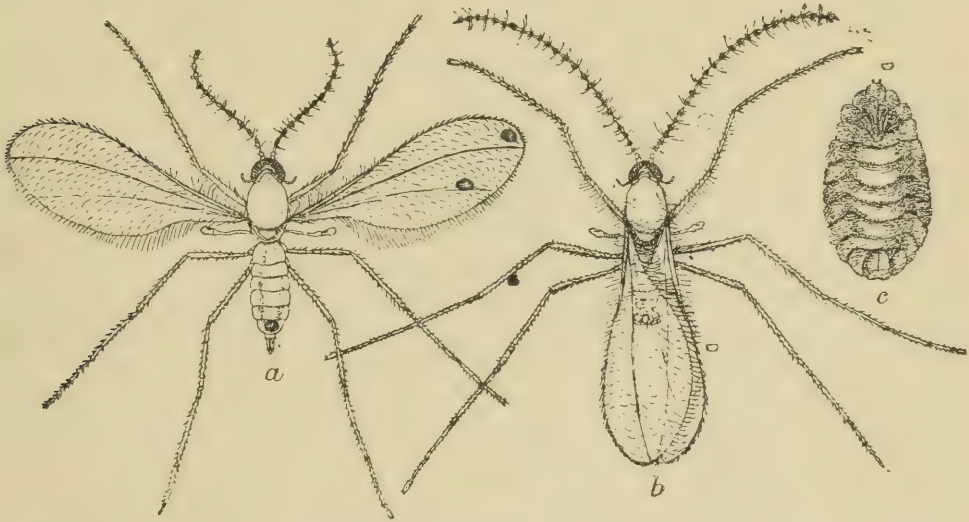


Fig. 9.—Wheat midge (*Diplosis tritici*): a, female fly ; b, male fly ; c, larva, ventral view—all enlarged. Marlatt.)

REMEDIAL TREATMENT.

When once a field of wheat becomes seriously infested little or nothing can be done to save the crop ; and it is often the wisest plan to plow it under and use the land for some other crop. Where there is a good catch of clover very few farmers, however, care to plow under. When the field is but slightly infested, a prompt application of some fertilizer, such as nitrate of soda, will often cause the young plants to send out stools or tillers which are unaffected by the fly. In this way good average crops are often obtained, even when the central shoots have been killed.

The farmer's efforts should lie along the line of prevention of infection of his crop. Several methods of control have been in use for many years, all of which are valuable under conditions which enable them to be carried out :

1. LATE SOWING.—Unquestionably the time of sowing is a very important factor in preventing the attack of the Hessian Fly. If sowing is postponed until the flies have deposited their eggs, then it is almost impossible for the fields to become infested in the fall, unless from belated flies which did not emerge from the "flax-seeds" at the usual time. Observations, however, go to show that climatic conditions influence to some extent the time of appearance of the flies after harvest ; and the last two seasons furnished ample evidence on this point. The summers of 1899 and 1900 were very dry, with no rain fall of any account until the last of August. The result of such a drouth was the postponement of the emergence of the flies until the middle of September, or rather, the continuous emergence of the flies from the first week to the middle of the fourth week in September in

many localities ; so that wheat sown between the first and twenty-first of September became infected. The majority of the flies appeared about the middle of September ; consequently, wheat sown after that date suffered less than that sown before.

It is true that the best time to sow fall wheat in Ontario is the first week in September, in case there are no disturbing factors such as the Hessian Fly ; but it is also evident that such fields run greater risk of infection than fields sown, say two weeks later. On this point, Dr. Fletcher makes the following pertinent remarks : (Report 1900, p 199).

“For many years previous to 1899 the Hessian Fly has done very little harm in Canada to fall wheat, and as a result of a great many experiments which are being carried out every year by the members of the Ontario Experimental Union, and other progressive farmers, it had become well known that the best crops were reaped from fall wheat sown at or before September 1. This, therefore, had given rise to the opinion that the proper time to sow fall wheat was at or about the date mentioned. This, however, is only true in such seasons and localities as the Hessian Fly and Wheat-stem Maggot are not abundant ; but in periods when these two serious enemies increase, as has been the case during the present season and last year, it will be found that the proper season to sow fall wheat and rye is subsequent to the time when the egg-laying females of the autumn broods of both of these insects have disappeared. For a year or two, at any rate, it will certainly pay farmers to acquaint themselves better with the life histories of these insects and the remedies which have been found successful in preventing the losses due to their attacks.”

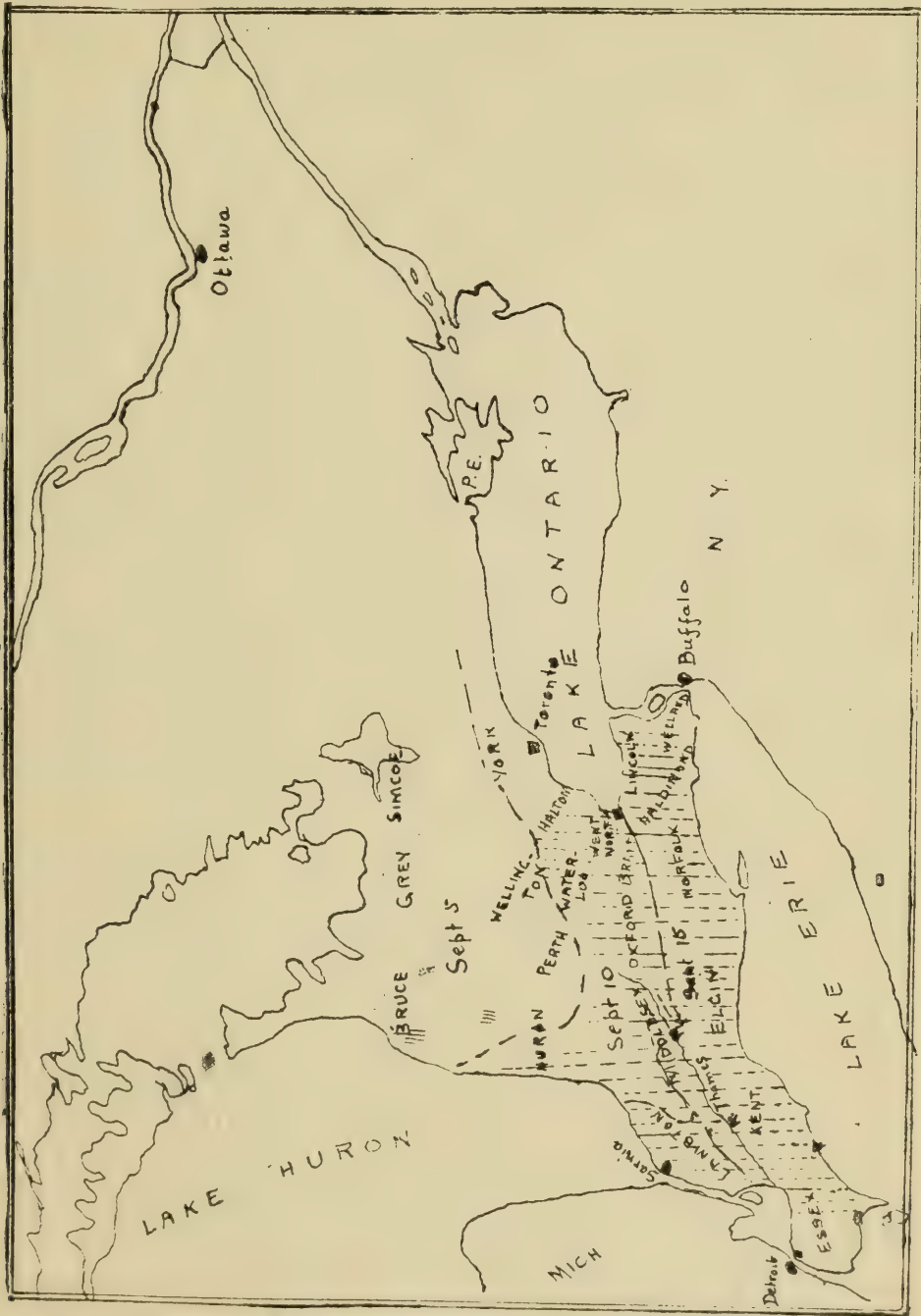
The date of emergence of the Flies is also dependent on latitude and geographical position, so that the safe time for sowing must be determined for each locality separately. Prof. Webster, of Ohio, has shown that “the dates after which sowing may be safely undertaken in the State of Ohio vary over a period of at least a month from the northern latitudes of the State to the southern latitudes ; or from approximately Sept. 10th in the north to October 10th in the south. Wheat sown after the dates mentioned, or after intervening dates in intervening latitudes, will germinate in normal seasons after the Hessian Fly has disappeared, and be free from attack.”

Just how far the dates of safe sowing in the various localities in Ontario may vary is not definitely known ; nevertheless some progress has been made the last two seasons along this line. It seems not safe to sow, in ordinary seasons, before September 15th in the counties bordering on Lake Erie, and the tract of land occupying the Valley of the Thames. In the next row of counties, including Lambton, North Middlesex, Oxford, Brant, Wentworth, and those bordering on Lake Ontario, the probable safe date would be September 10th ; while in the counties farther north, the safe date may be placed at September 5th. (See map).

The farmer, if he wishes to grow wheat free from the fly, must follow the season rather than the almanac, for the best date for one season may not be the best for another. For instance, a rainless August, such as we had in 1899 and 1900, will retard the emergence of the flies fully two weeks ; but an August with a considerable rain-fall during the last two weeks will bring forth the flies about the first week of September to deposit their eggs,—in which case it will be quite safe to sow according to the dates given above.

2. LAND WELL PREPARED FOR THE SEED.—Next to late sowing the preparation of the soil is probably the most important factor in fighting the Hessian Fly. The ground should be plowed early, and a good, rich, smooth,

well-pulverized seed-bed be secured ; and, besides, only the best seed wheat that can be procured should be sown. These factors are becoming fairly well recognized so far as the yield in ordinary seasons is concerned, but few as yet are aware how important good farming is in preventing injuries by the Hessian



Map of Ontario, showing the area of infestation by Hessian Fly. Note the safe dates for sowing in the three belts.
(Original.)

Fly. Prof. Webster, after fifteen years of study of the Hessian Fly, says: "I am satisfied that four-fifths of its injuries may be prevented by a better system of agriculture. For years I have seen wheat grown on one side of a division fence without the loss of a bushel by attack of this pest, while on the other side the crop was almost invariably more or less injured. No effect of climate, meteorological conditions, or natural enemies could have brought about such a contrast of results. The whole secret was in the management of the soil and the seeding."

Prof. Roberts, of Cornell University, also attaches special importance to the preparation of the land in combating the Hessian Fly. He says: "Much stress should be laid on the proper fitting of the land for wheat. Plowing should be done early, at least six weeks before sowing, to give abundant time for repeated working of the soil in order to recompact the sub-surface soil, and secure a fine, but shallow, seed-bed in which there has been developed by the tillage and action of the atmosphere an abundance of readily available plant food. Manures and fertilizers should be kept near the surface, and the young roots encouraged to spread out in the surface soil, thus avoiding much of the damage by heaving in winter and leaving the deeper soil for a fresh pasturage for the plants during the following spring and summer."

The same writer, after a long experience with the Hessian Fly, comes to the following conclusions: *1st.* That wheat raising need not be abandoned but the number of acres should be reduced until by reason of such reduction every acre sown will be raised under superior conditions. *2nd.* That the soil must be so well fitted and so fertile that a strong healthy growth will be secured in the fall, though the sowing of the seed be delayed 10 to 15 days beyond the usual time. Such preparation of the soil will also help the wheat to recover from any winter injury. *3rd.* That the Hessian Fly injures the wheat more on dryish and poor land than on moist, but well drained, rich soil. *4th.* That thick seeding and vigorous growth tend to ward off the Fly." (Cornell Bulletin 194, 1901).

Several of our own most progressive farmers corroborate the views of the two eminent authorities already quoted. Mr. E. D. Tillson, Oxford Co., says: "It is useless to endeavor to kill out the Hessian Fly by ceasing to grow wheat, as all farmers cannot be induced to do so. In this section the farmers who sowed good seed on well prepared land got fair crops even this year; while many careless ones did not get their seed back. Vigorous, strong growing wheat will withstand the fly, whether sown early or late." (*Farmers' Advocate*)

Mr. John Jackson, Lincoln Co., says: "In the district infected with the Hessian Fly. I think the acreage should be very much reduced, confined to what land can be put in the very best condition, and thoroughly well manured to insure a strong and vigorous growth. Extreme dates, and between which it would be safe to sow, are 8th of September to 8th of October. I would prefer from 10th to 20th of September." (*Farmer's Advocate*)

Mr. Jas. Mayhew, Kent Co., says: "Wheat sown in the same field on the same day and from the same seed, where there was a variety of soils, gave very different results according to the nature of the ground. The low or moist ground gave a fair half crop, while the wheat was entirely killed off on the dry ground. Our observations lead to the belief that want of fertility has largely to do with the amount of destruction caused by the Fly."

Mr. Alex. F. Ross, North Middlesex, says: "We have a field of wheat which was badly down with the Hessian Fly, but we have one piece in the field which did not have any Fly in it. It was an old barnyard cropped for four or five years."

Mr. H. J. Stevens, Kent Co., says: "So far as we have been able to find out, it has not been so much the kind of wheat as the locality and the condition the wheat was in. Sandy land has suffered most. This with early wheat is where the most damage is done."

Notes on Cultivation for Winter Wheat. At my request Prof. G. E. Day, of the Ontario Agricultural College, has prepared a short section dealing with the proper cultivation of land for winter wheat. I feel sure that this portion of the bulletin will be carefully read.

Owing to the fact that winter wheat is grown under such varying conditions as regards place in rotation, character of soil, etc., it is impossible to discuss all the phases of the question of cultivation. All that will be attempted, therefore, is the presentation of a few notes on methods that have proved successful. In the first place, it is generally admitted that winter wheat requires a soil comparatively compact below, mellow, and rich in available plant food near the surface, and possessing enough moisture to germinate the seed quickly. To secure this condition, various methods are adopted, and probably the oldest and best known of these is the

Summer Fallow.—Economy not considered, the summer fallow is perhaps the most effective way of preparing a fine seed-bed for winter wheat. The frequent cultivation allows air and bacteria to do their work in making plant food available, and also permits the accumulation of an abundant supply of moisture in the soil to help push the crop forward. It is a mistake, however, to plow a fallow frequently, because the most available plant food is near the surface. What plowing is done, should be performed early in the season, and practically all subsequent cultivation should be restricted to merely loosening the surface to a depth of not more than three or four inches.

The fallow, however, is an expensive method of preparing the ground for wheat, and on any reasonably well cultivated and fertile soil good crops of wheat can be grown without resorting to such an expensive process. Wheat is grown after a great variety of crops, but perhaps the two best crops to precede wheat are clover and peas. Both these crops are nitrogen collectors, and leave the surface soil comparatively rich in this important element, clover being particularly valuable in this respect.

Wheat after Clover.—The clover sod should be plowed before Aug. 1st, and if there is a good second growth to turn under, all the better. It should be plowed about $4\frac{1}{2}$ inches deep, using a skimmer, or chain, or both, to turn everything under. Immediately after plowing, the land is rolled to compact it, and then thoroughly harrowed to pulverize the surface and fill in all spaces between the furrows. Land treated in this way will absorb and retain moisture, and in a very short time the sod will rot. All that is necessary after this is an occasional stirring of the surface soil with a spring tooth cultivator. If weeds appear, broad points should be used on the cultivator. When it is time to sow the wheat, the soil will be found mellow, moist, and rich in available plant food.

Wheat after Peas.—In this plan it is best to have the peas follow sod, the sod being plowed early in the fall and thoroughly harrowed and cultivated. A plan that has given excellent results is to manure the ground during the winter or early spring before the peas are sown. This manure should be merely gang plowed under in the spring, keeping it as near the surface as possible; and it does not matter if the manure is not rotted before it is applied. By the time the peas are harvested, the manure is thoroughly decomposed and incorporated with the surface soil. Immediately after the peas are harvested, the land should be either gang-plowed or cultivated, then harrowed and allowed to lie until it accumulates sufficient moisture to germinate the seed, when it may be prepared for sowing. When the land is clean, a seed-bed can be prepared without either plowing or gang-plowing, the cultivator alone being used. If there are many annual weeds among the peas, the ground may be worked up with the spring tooth cultivator and harrowed immediately after harvest, and then allowed to lie for a week or two to encourage as many weed seeds as possible to germinate; then the ground may be gang-plowed before the wheat is sowed.

The advantage of applying manure before the peas are sown is obvious. When manure is applied after harvest, just before sowing wheat, it is difficult to incorporate it with the soil, because at that time the soil is comparatively dry, and the manure is apt to lie in the soil in an inert condition. It also makes the soil more open than it otherwise would be, and lessens its water-holding capacity, because the manure and soil are not well mixed. When the manure is mixed with the soil in the spring, however, it becomes thoroughly incorporated with the soil during the summer, and being kept at the surface, it forms a surface layer, rich in vegetable matter that is easily worked into a fine seed-bed in the fall.

Concluding Remarks.—As stated before, it is impossible to give directions for all possible conditions. Enough has been said, however, to indicate in a general way how to go about securing a moist and mellow seed-bed for the wheat. It is better in all cases to delay sowing until a somewhat later date, than to sow the seed in an extremely dry soil. When sown in a very dry soil, wheat germinates irregularly, and the plants are comparatively weak, slow-growing, and very liable to attacks by insects. A late vigorous growth is much better than an early, but weak, growth. To get the best results, both in the way of obtaining available plant food and abundant moisture, manure should be applied at least a month before the crop is sown, so as to insure thorough mixing of the soil and manure, and prevent the undue opening up and consequent drying out of the soil. The application of manure with the crop which precedes wheat, as described above, has many advantages, and, on the whole, is to be preferred wherever it is practicable.

3. TRAP CROPS.—The planting of trap strips of wheat about the middle of August in the field set apart for the wheat crop has been found very valuable wherever tried. The flies are attracted to the strips of wheat to lay their eggs; while later on the strips are plowed under deep and the entire brood destroyed. Trap crops are valuable for another reason. The farmer can ascertain for himself when the flies have ceased to deposit eggs and the safe time to begin sowing his seed wheat.

Moreover, if any of the supplemental fall brood appear before the usual time, the trap crop will attract them, and the young larvæ can be destroyed; otherwise, the eggs are laid on volunteer wheat and barley, to which no attention is usually given, and thus the brood is perpetuated. A trap crop should be destroyed within four weeks from time of sowing and plowed under so deeply that none of the flies in maturing will escape.

4. THE BURNING OF REFUSE.—Mention has already been made of the fact that the "flax-seeds" are frequently found higher than usual on the stem, viz, above the first joint from the ground, and that they are carried to the barn in the straw. During the threshing of the grain, the "flax-seeds" are separated in the chaff and screenings. It becomes, therefore, an important point to have all the dust and screenings destroyed, and to burn as much of the refuse as practicable, or to feed the screenings as early as possible to the stock.

5. THE BURNING OF THE STUBBLE.—As most of the "flax seeds" remain on the stubble after harvest, the practice of burning the stubble has for many years been one of the standard measures taken against the fly. This practice, however, is not a practicable one with most of our Ontario farmers, on account of the practice of seeding to grass and clover. The burning of the stubble would destroy the young meadow plants.

In some wheat districts the plowing under of the stubble is recommended when burning is impracticable. This method is a most effective one when it can be carried out properly and the stubble turned down to a depth of several inches and the field rolled. Unfortunately, however, this method is impracticable in Ontario, for the reason given above against the burning of the stubble. Whenever either of these methods become practicable, the stubble should be dealt with some time in August, before the flies appear to lay their eggs for the autumn brood.

FLY-PROOF VARIETIES OF WHEAT.

It is doubtful if there is any truly fly-proof variety of wheat in existence, but there are apparently certain varieties which are not injured so much as others. In the Experimental Plots at the Ontario Agricultural College, the Imperial Amber, Egyptian Amber, Michigan Amber, and Early Genesee Giant were but slightly infested; while the Dawson's Golden Chaff, Turkey Red, Buda Pesth, Clawson, Treadwell, and Red Chaff were badly damaged. At Thamesville, Kent Co., the Niger and Egyptian suffered least; while around Woodstock, the Red Bearded Walker's Reliable gave the best results when threshed. "In Stephen Tp., Huron Co.," H. Eilber, Esq., M.P.P., writes me, "Michigan Amber, and American Brand have stood the fly best." The Genesee Giant and Arcadian, also, as a rule, gave fairly good returns in most localities. Throughout the infested areas, Dawson's Golden Chaff suffered very severely, and will not yield more than one third of an average crop.

In New York State, however, Dawson's Golden Chaff proved to be almost fly-proof, and, in almost every instance, gave good results. Prof. Roberts says: "It is difficult to explain why Dawson wheat should be so free from damage from the Fly in New York and not in Canada, the place of its origin; neither can we tell what characteristics enable one variety to resist while another succumbs. Vigor of growth, no doubt, exerts much influence, but not all." The other resistant varieties in New York State are Prosperity, No. 8, Democrat, Red Russian, and White Chaff Mediterranean.

CO-OPERATION OF THE FARMERS IS NECESSARY.

In dealing with most insect pests, and especially with the Hessian Fly, it is very important that all the farmers in the locality should co-operate in the matter. Everyone should sow as late as practicable, and as near the same time as possible, for if some fields are sown early, they may easily supply flies enough in the spring to infest all the neighboring fields. This fact was very noticeable this year; for fields which were free from the fly last fall, were badly damaged before harvest. Several correspondents, unacquainted with the life history and habits of the fly, maintained that it made no appreciable difference whether wheat was sown late or early. One well-informed Middlesex correspondent, however, writes me on this matter as follows: "I plowed up 15 acres Gold Coin last spring, and kept Dawson's Golden Chaff, which you saw; and it then was comparatively speaking pretty free; but my neighbors, however, supplied me with plenty of breeding stock with the result of my having only 14 bushels per acre, the biggest yield yet announced in this neighborhood. I think the average will not exceed 5 bushels for two or three townships."

In conclusion, it may be stated frankly that there are many peculiar features in connection with the Hessian Fly which have not yet been ex-

plained, or else are difficult to explain, and that many more careful observations will have to be made before everything is known regarding the life-history of the pest. Among these peculiar features connected with the Hessian Fly I may be permitted to mention some which I observed while making investigations in the infested wheat fields in the spring of this year. I frequently found early sown fields infested to a less extent than those sown later. However, a probable explanation suggested itself; the fields were sown before the emergence of the fly, and the wheat plants had attained a good growth before the maggots made their appearance. The more tender plants of the later sown fields were more attractive to the flies, and the consequence was the deposition of the eggs on the younger plants. Again, I observed in one or two localities, where seeding was done about the same time, but too early to escape the fly, that one or two fields were almost free from infestation. The only cause I could assign for this peculiarity was the presence of woods which nearly surrounded the fields free from infestation. And again, fields on the leeward side of old stubble-infested fields were often comparatively free from the fly, while those on the windward side were badly infested. In these cases the wind was very probably the distributing factor. These observations, I may repeat, were made before the spring brood had an opportunity to make itself felt.

SUMMARY.

1. The Hessian Fly is double-brooded,—the fall brood appearing in September and injuring the young plants of fall wheat; the spring brood appearing in May and June and injuring the more mature stage of the fall wheat as well as spring wheat and barley.

2. For the present, its ravages are confined chiefly to the south-western counties of the Province.

3. Parasites which prey upon the Hessian Fly are apparently few in number, and are doing but little to keep the pest in check.

4. The best preventive measures are (a) late sowing, (b) thorough preparation of the land (c) stimulation by fertilizers, (d) trap crops, (e) burning of refuse after threshing, and (f) burning or plowing under of infested stubble when practicable, (g) co-operation among the farmers themselves.

5. There is no absolutely fly proof variety of wheat. The Genesee Giant, Arcadian, Walker's Reliable, Michigan Amber, and Egyptian Amber suffered less than Dawson's Golden Chaff, Turkey Red, or Democrat.

6. Climatic conditions influence the time of appearance of the fly in the autumn. A dry rainless August will retard the appearance sometimes ten days or two weeks. In normal seasons, with rain during the last two weeks in August, the safe date for sowing varies in different localities, from Sept. 5th in northern counties to Sept. 15th in the counties along Lake Erie. (See map.)

It cannot be emphasized too strongly that, in order to obtain the best practical results, total reliance should not be placed on any one of the methods outlined above; but, instead, an intelligent combination of two or more of the measures should be adopted.

“Sow as late as your local conditions will permit, sow intelligently in a well-prepared seed-bed and on good soil, get your neighbors to do the same, and you will circumvent the Hessian Fly nearly every time.” (Slingerland.)

Ontario Agricultural College and Experimental Farm.

THE CONTINUOUS PASTEURIZATION OF MILK AT DIFFERENT TEMPERATURES FOR BUTTERMAKING.

BY PROF. H. H. DEAN, B.S.A., AND PROF. F. C. HARRISON, B.S.A.

The constant striving of agricultural countries to produce the best articles at the lowest possible cost for the English markets has resulted in very keen competition, and new competitors are constantly entering the field. We have lately heard that Siberia is sending considerable quantities of butter to England, and that special refrigerator trains and steamers have been built in order to handle this product. At present, this butter, although good in texture and make, lacks uniformity and flavor; but these defects will probably be speedily remedied, as the Russians have lately sent experts to Denmark, to study the methods followed in that country, and have even imported skilled dairymen for the purpose of instructing the Siberian peasants. Hence it behooves the Canadian maker to take advantage of every new method which is shown to be of value in producing a first-class article.

As it has been the strenuous endeavor to cheapen production in those countries which make a specialty of dairying, there must be good grounds for their adoption of pasteurization, an operation which increases the cost to a considerable extent in the outlay, both for apparatus and for the production of the heat required in the operation.

That buttermakers should incur this additional expense is very good evidence that pasteurization is an important operation, and that without it there is difficulty in obtaining the best results.

The comparison that has often been made between the farmer and the dairyman, explains the chief reason for pasteurization. The farmer cultivates his land and prepares his soil for the special crops he intends to grow; he eradicates as far as possible all weeds, and he selects with care a good variety of seed, from which he expects to reap as he has sown. The dairyman also prepares his soil, the raw milk, by heating it to such a temperature as will kill all or the greater number of bacteria which may be present, these being his weeds; then he seeds his milk with a selected variety of micro-organism found to produce a good flavor in butter; and he also expects to reap even as he has sown. These two points—first, the preparation of the milk by pasteurizing, and, secondly, the seeding with selected races of bacteria—have enabled all makers to secure the great desideratum, *uniformity of product*, which is of such importance to both producers and consumers

In addition to this uniformity, the butter-maker is incidentally able to drive off certain unpleasant odours that may be present in the milk supplied to him; and the keeping quality of his product is thereby increased, because he has killed the larger number of the harmful bacteria, which, if they had remained living, might have impaired the quality of his butter.

Further, if the right temperature is used, all *disease-producing organisms* are destroyed, including the bacillus tuberculosis, which is very frequently found in butter. This fact alone will add considerably to the comfort and security of the consumer.

The whole problem of pasteurization is a question as to the proper temperature; and unfortunately this is a matter of some complexity.

The effect of temperature on bacteria depends on the degree of heat and the length of exposure,—a low degree of heat and a long exposure being equivalent to a higher temperature and shorter exposure; but the former takes too much time and is not practicable, while the latter is apt to give a cooked taste to the milk. Hence we have two methods of pasteurizing for two different objects, which have been termed the Discontinuous and Continuous systems.

The Discontinuous System, or a system of pasteurizing from the milk-dealer's standpoint, requires that all disease-producing bacteria be destroyed, that the milk possess good keeping quality, and that the taste be not injured. In order to obtain these requisites, the milk must be heated in 140 degrees F., be stirred during the process, to prevent the formation of a pellicle, or scum, on the surface; and be held at this temperature for 15 to 20 minutes. This temperature, for this length of time, has been found sufficient to kill the bacillus tuberculosis, the most resistant disease-producing germ found in milk.

The Continuous System, or a system of pasteurization from the buttermaker's standpoint, was first introduced by the Danes. By this method, the milk flows in at the bottom of a vessel heated by steam, is whirled against the side, and (having reached the desired temperature) flows continuously from an outlet in the top. The object is to kill most of the bacteria present in the milk. By a recent enactment in Denmark, this temperature has been fixed at 85 degrees C. (185 degrees, F.) as Dr. Bang has shown that the tubercle bacillus or bacillus tuberculosis, is killed in milk heated to this temperature. By this means, the buttermaker gets rid of bacteria that might subsequently prove harmful, and prepares the milk for his selected bacteria, or culture, as it is usually called.

In Canada and the United States, the usual pasteurizing temperature is 158 degrees F., (70 degrees C.) to 160 Degrees F., a temperature selected because by the discontinuous system a cooked taste was imparted to the milk at higher temperatures; but, as pointed out by a recent New York Experiment Station bulletin, the American experimenters went astray in their reasoning, "for the cooked taste is the result of an exposure of hot milk to oxygen, and the cooked flavor does

not attach itself tenaciously to the fat, and butter made from highly heated milk that may have a cooked taste, immediately after churning loses this objectionable flavour in a short time."

For six years the Dairy Department of the College has been conducting experiments to determine the effects of pasteurization on milk and cream for buttermaking.

To indicate the advancement in methods of pasteurization since 1896 and 1897, we quote from the annual report of the College for those two years :

"Owing to the lack of suitable appliances, most of our pasteurizing experiments were conducted by simply heating the cream contained in an ordinary shot-gun can (set in a hot water bath) to a temperature of 160 degrees. In about 20 minutes afterwards, the cream was cooled to ripening temperature and the "starter" was added."—(1896.)

"It has been suggested that pasteurizing the whole milk *before* separating was preferable to heating the cream and skim-milk *after* separating. A vat of milk was heated to a temperature ranging from 95 degrees to 98 degrees, and half of it was separated. The other half was then heated from 150 degrees to 160 degrees and separated. All the heating was done in a vat having a capacity of about 800 pounds. The chief difficulty was in preventing the milk from cooking on the sides of the vat. By carefully regulating the steam, and by keeping the milk in motion, this trouble was largely prevented."

The experiments instituted at the College Dairy in 1901 were to determine the quality and keeping property of butter made from milk pasteurized at different temperatures. In the Bacteriological Laboratory, our attention was directed to the number and kind of bacteria in the milk before and after pasteurization at the different temperatures employed.

Tests at the Wisconsin Station, with the Reid pasteurizer, at temperatures between 150-165 degrees F. showed considerable variation. The lowest number in the pasteurized sample was 87,400 bacteria per c.c., and the highest 17,500,000 per c.c.,—a very wide difference. The average number left (14 tests) after pasteurizing, was about 1,800,000, or nearly 92 per cent. of the bacteria were destroyed. But this hardly represents the variation in the effect of the heating; for in some cases 40 per cent. of the bacteria survived.

The Pennsylvania Station, whilst giving no numerical data, states "that heating to this temperature (155-158 degrees) destroyed few, if any, of the bacteria present in the milk."

The New York Experiment Station have fuller data on this point. At 158 degrees F., they found that the pasteurizing action was very uncertain, and that this temperature lies near the lower limit of the killing effect of heat applied in this way; and, when operating a pasteurizer in ordinary practice, temporary reductions of temperature are

almost sure to occur. Hence the killing effect below this temperature is very slight.

Observations by the same station were made at 176 degrees F., and the results of pasteurization at this temperature 'showed a surprising reduction in the germ life, and this reduction was accomplished with very slight variation on each of the 25 days on which the tests were made. These tests gave an average of only 117, with a maximum of 297 and a minimum of 20, living germs per c.c. in the pasteurized milk'

Seven tests at the temperature used in Denmark, 185 degrees F., gave an average of 115 living germs per c.c.; and, as the writers remark, 'were it not for the fact that in the present state of our knowledge, it is believed that a heating of milk to 185 degrees F. in a continuous pasteurizer, is necessary to remove all danger of tuberculosis, the use of 80 degrees C. (176 degrees F.) in pasteurization for butter-making would leave little to be desired.'"

The Pasteurizers.—The pasteurizers used in the experiments here were the "Reid" in March and the first seven days in April, and the "Lister" for the remainder of the season.

The Reid machine is driven with a belt and, in addition to heating the milk, elevates it several feet. The milk is heated by passing over a steam heated surface, and it is kept in a circular motion by means of paddles which revolve in the milk. The weaknesses of the Reid pasteurizer are: The difficulty of maintaining a uniform temperature, and the fact that it requires a firm foundation for the large machine. Its strong point is that it not only pasteurizes the milk, but acts as a milk pump for lifting the milk from the receiving vat to the separator.

The Lister machine is driven with steam directly from the boiler, and is what is commonly called a turbine pasteurizer. It does not elevate the milk above the outlet near the top of the machine, and must be placed above the separator in order to have the milk flow into the separator. The milk for this machine was pumped from the receiving vat directly into the feeding funnel of the pasteurizer; and the temperature of the milk, which was received at a temperature of about 60 degrees, was raised from 125 to 130 degrees while passing through the machine, when fed at the rate of about 2,600 pounds of milk per hour. Milk which was heated above 185 degrees, required a preliminary heating before entering the pasteurizer. The three weak points of the Lister machine are: That it does not elevate the milk, that the centre bearing of the paddles fills with milk if the machine is allowed to get too full, and that the turbine has not at all times sufficient force to keep the milk in constant motion. The strong points of the Lister are that it occupies a small space, no belt is required to run it, and no special foundation is needed.

The Danish Pasteurizer, invented by Fjord, has of late been considerably altered, because the Danes are now compelled to heat the

milk to 85 degrees C., and the old form of apparatus is not capable of economically heating the milk to this temperature. The improvements are as follows :

A series of rings are soldered on the heating surface of the pasteurizer. These rings slope downwards, giving the appearance of eaves arranged concentrically around the heater. These rings gather and shed the water formed by condensation of the steam on the heating surface; for this water deposited as a thick layer upon the surface of the heater, is a bad conductor, opposes the resistance, and enfeebles the penetration of the heat to the milk, which is thrown by the agitator against the inner surface of the heater.

The agitator has also been improved by the addition of horizontal plates on the paddle, to prevent the milk from taking too vertical a movement in the pasteurizer; and this improvement helps to give the same temperature to all parts of the milk, and prevents frothing.

A third improvement is an air-cock fixed on the water-trap, which allows the air carried along into the steam jacket to escape.

No doubt the efficiency of the Lister and Reid pasteurizers could be increased considerably by attaching the improvements suggested by Prof. Storch, of the Experimental Laboratory of the Royal Agricultural and Veterinary College of Copenhagen.

DAIRY DATA.—In our Dairy, the experiments consisted of several series :

Series I. In the first, about 3,000 lbs. of milk was mixed in a receiving vat. One-half of several lots was separated at a temperature of about 90 degrees F., and the other half was pasteurized at temperatures of 140, 160, and 185 degrees F.

Series II. In this series, 3,000 lbs. of milk was well mixed. One-half of several lots was heated to 140 degrees F. before separating; and the other half was heated to 160, 185, and 195 degrees F.

Series III. In this series, one-half of several lots was heated to 160 degrees, and the remainder to 185 degrees.

Series IV. In this series, samples of butter made from milk heated to 185 and 195 degrees were compared.

Series V. In this lot, one vat of about 3,000 lbs of milk was divided into four parts. During April and May, each of these parts was heated to 140, 160, 185, and 195 degrees respectively; but during March, July, and August, the temperatures used were 90, 140, 160, and 185 degrees.

Series VI. In the last series, experiments conducted during March and June, vats of milk were divided into two lots. One part was left unpasteurized, and the other was pasteurized at about 160 degrees.

Boiler Pressure.—The boiler used for generating steam at the Dairy is a 50 horse-power boiler situated about 50 feet from the pasteurizer. An average pressure of 75 to 80 pounds was maintained as far as possible. When the steam pressure was reduced below 70

pounds, it was difficult to maintain the milk at 185 to 195 degrees, without reducing the feed. It is evident that, if pasteurizing at 185 degrees is practised, a large boiler and steady steam pressure will be required.

During the year nearly 100,000 lbs. of milk were used in the experiments. For April and May milk was received four times a week. The average percentage of fat in the milk of the first four series ranged from 3.64 to 3.69. The temperature of the milk when received was 40 to 60 degrees in March and April. In May it was about 59 degrees, June 60 degrees, July and August 65 degrees. The average acidity in the first four series, when the milk was delivered, was .17 to .18 per cent. The average acidity of the cream at the time the culture for ripening was added, varied from .088 per cent for the lots heated to 160 degrees to .118 for the lots heated to 140 degrees. Those heated to 185 degrees had an average acidity of .114; and those lots of cream from milk heated to 195 degrees before separating had an average of .104 per cent. of acidity at the time the culture was added. At the time of churning, there was very little difference in the acidity of the different lots—being from .5 to .6 per cent.

The percentage of fat in the cream in the first four series varied from an average of 32.7 in the lots separated at 140 degrees to 28.6 in the lots separated at 195 degrees. There was practically no difference in the fat lost in the skim-milk and buttermilk, whether the milk was separated at 140, 160, 185, or 195 degrees. The skim milk averaged one-tenth of one per cent. fat, and the buttermilk averaged about .15 per cent. fat. The temperature of the cream at the time the culture was added varied from 66 to 68 degrees. The average temperature for ripening the cream was about 65 degrees for all the lots. The average churning temperature was 49 degrees for all lots. The average time required to churn the cream was 41 minutes for the lots separated at 140 degrees, 39 minutes for the lots separated at 160 degrees, 38 minutes for the lots separated at 185 degrees, and 36 minutes for the lots separated at 195 degrees.

The percentage of moisture and salt in the butter were: Unpasteurized, 13.690 per cent. moisture and 2.15 per cent. salt. Pasteurized at 140 degrees, the moisture and salt were, respectively, 13.128 and 2.57; at 160 degrees, 13.224 and 2.85; at 185 degrees, 13.994 and 2.55; at 195 degrees, 13.561 and 2.62. All the butter was salted at the rate of one ounce of salt per pound of butter.

After working, the butter in the first four series was put into pound prints and wrapped in parchment butter paper. One print of each lot was numbered by the buttermaker, when it was placed in cold storage at an average temperature of 40 degrees. The prints were scored by numbers, so that the scorer did not know what kind of butter he was scoring. Nearly all of the butter was scored twice—once when made about two weeks, and again when one month to six weeks old.

Scoring of Series I.

Comparison of butter made from unpasteurized milk with butter made from milk heated to 140, 160, and 185 degrees.

No. of Samples.	Kind of Butter.	Average flavor. Max. 45.	Average grain. Max. 25.	Average color. Max. 15.	Average Total. Max. 100.
{ 6	Unpasteurized.....	39.8	25	14.5	94.3
{ 6	Pasteurized at 140 degrees.....	41.2	25	14.5	95.7
{ 8	Unpasteurized.....	34.9	24.5	14.4	88.8
{ 8	Pasteurized at 160 degrees.....	37.1	25	14.1	91.2
{ 6	Unpasteurized.....	40.3	25	14.5	94.8
{ 6	Pasteurized at 185 degrees.....	41.5	25	14.3	95.8

Scoring of Series II.

Comparison of butter made from milk pasteurized at 140 degrees with butter made from milk heated to 160, 185, and 195 degrees F.

{ 9	Pasteurized at 140 degrees.....	38.9	24.8	14	92.7
{ 9	Pasteurized at 160 degrees.....	39.9	24.9	14	93.9
{ 9	Pasteurized at 140 degrees.....	39.6	25	14	93.6
{ 9	Pasteurized at 185 degrees.....	40.4	25	14.1	94.5
{ 6	Pasteurized at 140 degrees.....	40.1	24.8	14.3	94.3
{ 6	Pasteurized at 195 degrees.....	39.8	24.8	14.3	94

Scoring of Series III.

Comparison of butter made from milk pasteurized at 170 degrees with butter made from milk pasteurized at 185 degrees F.

10	Pasteurized at 160 degrees.....	40.7	25	14.2	94.8
10	Pasteurized at 185 degrees.....	41.0	25	14.1	95.1

Scoring of Series IV.

Comparison of butter made from milk pasteurized at 186 degrees with butter made from milk pasteurized at 195 degrees F.

7	Pasteurized at 185 degrees.....	41.0	25	14	95
7	Pasteurized at 195 degrees.....	40.8	25	14	94.8

In the fifth series, where vats of 3,000 lbs. milk were divided into four different lots during April, May, July, and August, the average percentage of fat in the milk ranged from 3.7 to 3.8. The per cent. of acidity in the milk delivered was .17, and that of cream at the time of adding culture was .09; and at the time of churning it was .55 for the lots heated from 140 degrees to 195 degrees, and .59 for the lots separated at ninety degrees. The percentage of fat in the lots of cream ranged from 27.6 to 32. The percentage of fat in the skim-milk was less than one-tenth of one per cent. for all. The fat in the buttermilk was about .15 per cent. for the pasteurized lots, and .25 for the unpasteurized samples. All the lots had the cultures added at an average temperature of 68 degrees, were ripened at 65 degrees, and were churned at 46 degrees to 47 degrees. The average time required to churn the unpasteurized lots was 47 minutes; the 140 degrees lots, 40 minutes; the 160 degrees lots, 39 minutes; the 185 degrees lots, 37 minutes; and the 195 degrees lots, 42 minutes.

Scoring of Series V.

Comparison of butter made from unpasteurized milk and butter made from milk pasteurized at 140 degrees, 160 degrees, 185 degrees, and 195 degrees.

No. of [Samples.	Kind of Butter.	Average flavour. Max. 45.	Average grain. Max. 25.	Average color. Max. 15.	Average Total. Max. 100.
2	Unpasteurized.....	39.2	25	14.2	93.4
4	Pasteurized at 140 degrees....	39.2	25	14.1	93.3
4	Pasteurized at 160 degrees.....	39.6	25	14.1	93.7
4	Pasteurized at 185 degrees.....	41.1	25	14.4	95.5
1	Pasteurized at 195 degrees.....	40.8	24.5	13.5	93.8

In the sixth series, during March and June, 26,600 lbs. milk, testing an average of 3.84 per cent. fat, was equally divided; and one-half was separated at about 90 degrees and the other half was pasteurized at 160 degrees. The per cent. of acidity in the milk when received was .155. The acidity of the unpasteurized cream at the time of adding the culture was .154, and that of the pasteurized cream was .131. Both lots had about the same acidity at the time of churning, viz., .5 per cent. The percentages of fat in the cream were 30 per cent. in both cases. The fat in the skim-milk in both cases was less than one-tenth of a per cent., and the buttermilk averaged .15 per cent. fat. Both lots were ripened at the same temperature (64 degrees) and were

churned at the same temperature (47 degrees). The average time of churning was 41 minutes for the unpasteurized cream and 37 minutes for the pasteurized cream.

Scoring of Series VI.

Comparison of butter made from unpasteurized milk, with butter made from milk pasteurized at 160°.

No. of Samples.	Kind of Butter.	Average flavor. Max. 45.	Average grain. Max. 25.	Average color. Max. 15.	Average Total. Max. 100.
{ 10	Unpasteurized	38 0	24.8	14 4	92.90
{ 10	Pasteurized at 160 degrees	39.4	25	14.2	93.65
{ 3	Unpasteurized, March	33.3	24.3	14.3	87
{ 3	Pasteurized at 160 degrees March.	35.8	25	14.2	90
{ 7	Unpasteurized, June	40	25	14.4	94.4
{ 7	Pasteurized at 160 degrees, June..	41	25	14.2	96.2

The keeping quality of boxed butter from milk pasteurized at different temperatures.

Date of Making.	Temperature.	Scores for flavor at end of			
		14 days.	60 days.	125 days.	164 days.
July 5	Unpasteurized	42	36	36	.....
Aug. 5	"	43	39	.....	.....
Apr 24	Pasteurized, 140 degrees	42	32	.....	.....
May 27	" 140 "	43	42	42	40
July 5	" 140 "	41	34	36	.....
Aug. 5	" 140 "	43	38	.....	.....
Apr 24	" 160 "	42	37	.....	.....
May 27	" 160 "	43	41	40	39
July 5	" 160 "	41	37	35	.....
Aug. 5	" 160 "	42	39	.....	.....
Apr. 24	" 185 "	43	38	41	41
May 27	" 185 "	42	41	40	.....
July 5	" 185 "	42	41	.....	.....
Aug. 5	" 185 "	43	40	.....	.....
May 27	" 195 "	42	41	39	41

Keeping Quality of the Butter.—Butter for cold storage and for export must possess *keeping quality*, a point which is usually overlooked in judging butter. If we are to compete in the British markets, Canadian butter must overcome the prejudice which exists in England, that it will not “keep.”

Our experiments during the past six years all indicate that pasteurization improves the flavor and keeping quality of butter made from winter milk. In summer, when conditions are more favorable for the making of fine-flavored butter, there is not so much difference in the flavor of the butter when first made, whether pasteurized or not. However, when samples are kept for some time—60 to 160 days—there is quite a marked difference in favor of the butter made from pasteurized milk. Our experiments for the past two years also show that the higher temperature of 185° is more favorable in the production of “keeping quality” than the lower temperatures of 140° to 160°.

Bacteriological Data.—The culture media used were ordinary lactose agar and whey gelatine. Usually 4 plates from each sample were poured, two of lactose agar and two with whey gelatine. The whey gelatine gave very satisfactory results. It was made from whey, boiled and filtered, to which was added $\frac{1}{2}$ per cent. of peptone, $\frac{1}{8}$ per cent. of Heyden's Nutriment (Nährstoff Heyden), and 10 to 12 per cent. of gelatine.

The agar plates were kept at 20 to 30° C. (83 to 86° F.), and the gelatine plates at 20 to 21° C. (68 to 70° F.). Of the two kinds of media, whey gelatine was preferable, as the colonies of the lactic acid bacteria were larger; and the spreading surface colonies on the agar plates made counting rather difficult. But little numerical difference between the plates made from the different media, was noticed.

The samples of unpasteurized milk were taken directly from the receiving vats, after the milk from all the different patrons was thoroughly mixed.

The temperature of the pasteurized milk was taken by a thermometer inserted close to the outlet of the milk from the pasteurizer; and these samples were taken from the outflowing milk in large sterilized test-tubes, and brought to the laboratory, where the analyses were made at once.

Dilution.—The sample was thoroughly shaken, and $\frac{1}{2}$ c. c. was added to 10 c. c. of sterilized water, and $\frac{1}{2}$ c. c. of this mixture again added to 10 c. c. water, and a small fraction of this was added to the culture medium, and plates poured. By means of this dilution, the colonies were not too crowded on the plates; so they could be easily counted. With the pasteurized sample no dilution with sterilized water was made, about 1-20 to 1-30 of a c. c. of the pasteurized milk being directly added to the culture medium.

*Results of Continuous Pasteurization of Milk at 140-146° F.
(60-63C.)*

Thirteen tests, percentage of bacteria killed, 96.42.

Date.	Pasteurizing temperature.	Temperature of milk before pasteurizing.	Acidity.	Unpasteurized.	Pasteurized.
				Average No. of germs per c. c.	Average No. of germs per c.c.
April 10	146	54	.15	8,090,000	243,600
" 12	140	52	.16	3,736,000	235,000
" 15	142	54	.18	3,705,000	243,500
May 1	144	58	.15	8,736,000	557,000
" 4	140	58	.17	13,400,000	367,000
" 18	140	61	.19	14,510,000	837,000
" 21	140	61	.17	33,380,000	800,000
" 27	140	58	.17	16,250,000	667,000
" 29	140	60	.17	17,000,000	650,000
June 3	140	60	.17	15,670,000	720,000
" 6	140	58	.16	15,723,000	672,000
" 8	140	60	.17	22,340,000	812,000
Aug. 5	140	.....	.....	51,900,000	1,400,000

*Results of Continuous Pasteurization of Milk at 160-165° F.
(71-74° C.)*

Twenty tests, percentage of bacteria killed, 99.95.

Date.	Pasteurizing temperature.	Temperature of milk before pasteurizing.	Acidity.	Unpasteurized.	Pasteurized.
				Average germs per c.c.	Average germs per c.c.
Mar. 29	160	53	.15	507,600	510
April 1	160	46	.16	1,402,100	8,950
" 3	164	52	.15	288,000	510
" 6	160	54	.16	2,784,000	410
" 8	160	53	.15	7,040,000	9,025
" 10	160	54	.15	8,090,000	650
" 17	160	56	.19	9,090,000	2,300
" 19	160	46	.17	1,820,000	93,800
" 29	165	60	.21	25,100,000	11,420
May 1	160	58	.15	8,736,000	23,200
" 15	165	60	.19	4,050,000	15,700
" 16	160	60	.18	1,511,000	16,800
" 18	160	61	.19	14,510,000	13,000
" 23	160	61	.17	13,275,000	7,400
" 27	160	58	.17	16,250,000	12,000
" 28	160	62	.15	23,400,000	6,300
June 3	160	58	.16	15,670,000	4,700
" 5	160	60	.....	16,274,000	11,700
" 7	162	58	.16	31,113,000	8,370
Aug. 5	165	.....	.....	51,900,000	10,200

Results of Continuous Pasteurization of Milk at 185° F. (85° C.)

Fourteen tests, percentage of bacteria killed, 99.99953.

Date.	Pasteurizing temperature.	Temperature of milk before Pasteurizing.	Acidity.	Unpasteurized.	Pasteurized.
				Average No. of germs per c. c.	Average No. of germs per c. c.
April 12	185° F.	52	.16	3,736,000	80
" 17	185	56	.19	9,090,000	144
" 22	185	56	.12	2,964,000	44
" 29	185	60	.21	25,100,000	30
May 4	185	58	.17	13,400,000	33
" 15	185	60	.19	4,050,000	30
" 22	185	62	.17	18,500,000	112
" 23	185	61	.17	13,275,000	60
" 27	185	58	.17	16,250,000	56
" 28	185	62	.15	23,400,000	200
" 29	185	60	.17	17,000,000	24
" 30	185	61	.16	14,500,000	90
June 4	185	60	.16	22,110,000	117
Aug. 5	185	.....	.....	51,900,000	112

*Results of Continuous Pasteurization of Milk at 195 to 200° F.
(94 to 93° C.)*

Eight tests, percentage of bacteria killed, 99.99968.

Date.	Pasteurizing temperature.	Temperature of milk before Pasteurizing.	Acidity.	Unpasteurized.	Pasteurized.
				Average No. of germs per c. c.	Average No. of germs per c. c.
April 15	200	54	.18	3,705,000	16
" 19	195	46	.17	1,820,000	77
" 22	195-200	56	.12	2,964,000	16
May 16	195	60	.18	1,571,000	87
" 21	190	61	.17	38,380,000	96
" 22	195	62	.17	18,500,000	30
" 27	195	58	.17	16,250,000	0
" 30	195	61	.16	14,500,000	0

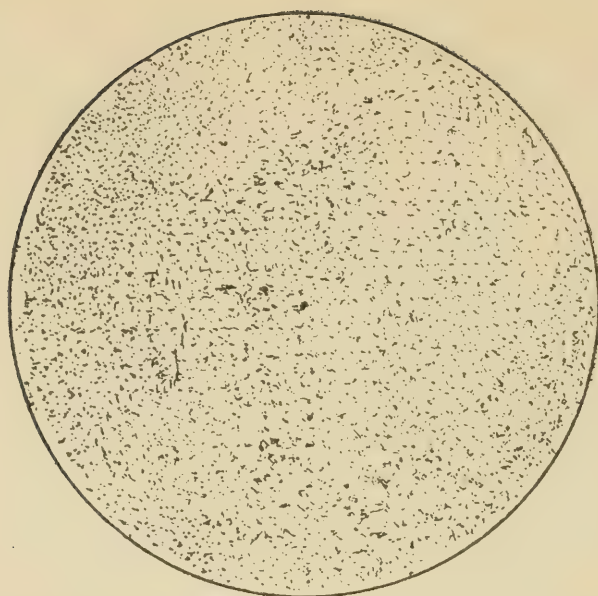
The Bacteriological Results.—The milk used in the various pasteurizing experiments may be said to have been of good quality. In only one or two instances did the acidity exceed 0.2 per cent. of lactic acid, an arbitrary standard proposed by Russell, as it was shown by that experimenter that milk having a low percentage of acidity, was, as a rule, freest from spore-producing bacteria; and the standard mentioned (0.2 per cent.) was found to give good results in practice.

A comparison of the acidity with the number of bacteria per c. c. in any of the tables will show, however, that no definite relation exists between the two; as, for instance, the bacterial content in one sample was over 38 millions, and in another two millions, and yet the acidity in both these cases was the same, viz., 0.17 per cent. The explanation of this fact is that large numbers of bacteria were present, which either produced no acid or else but a slight amount. Bacteria belonging to the colon group were often present in large numbers; and these, whilst producing acid, do so to a far less extent than the true lactic acid bacteria.

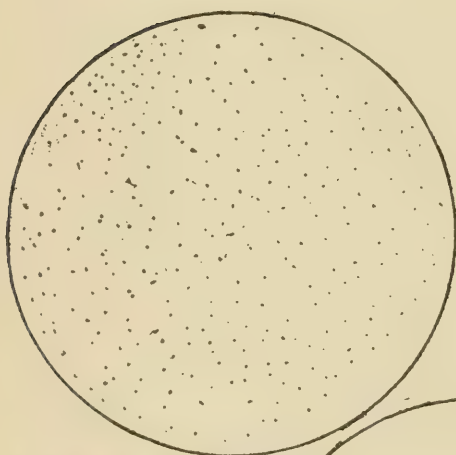
The effect of continuous pasteurization at 140 degrees is undoubtedly efficient, as 96.42 per cent. of the bacteria are killed; but we must remember that the effect of this temperature is just on the border between efficiency and non-efficiency. In practice there is apt to be a lowering of the temperature from time to time, perhaps due to lessened steam pressure, too great an inflow of milk, or other causes; and when this happens, there is a great loss of efficiency, and the number of bacteria which escape destruction is greatly increased.

Unfortunately, too, the desirable lactic acid bacteria necessary for buttermaking are the first to succumb; and the undesirable bacteria, hardier and more resistant to adverse influences, are either not affected or only to a slight degree by this temperature; and if left, even in moderate numbers, they rapidly increase when the cream is placed in the ripening vat, and may give rise to "off flavors." A glance at the accompanying diagram (I.) will show the large number of bacteria which remain living after continuous pasteurization at 140 degrees—too many which are as a rule undesirable for the best results.

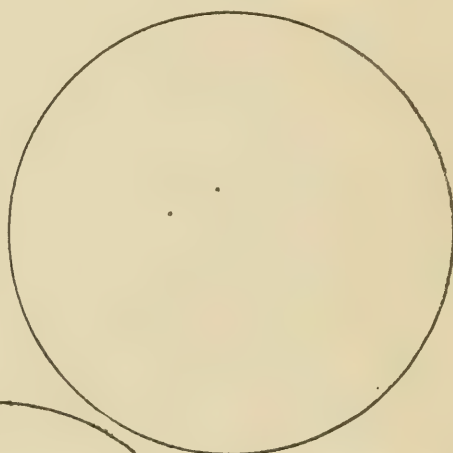
At 185 degrees, however, the results are much better (diagram III.), probably all bacteria except those forming spores being killed. We must also remember that this temperature has been shown by Prof. Bang of Copenhagen to be sufficient to kill the tubercle bacillus (*bacillus tuberculosis*) thus removing a source of danger to man and animals.



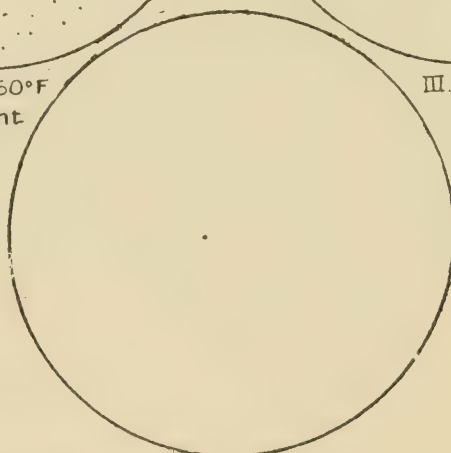
I. Pasteurised at 140° F.
15,776 Bacteria per cubic centimetre (16 drops)



II. Pasteurised at 160° F.
321 Bacteria per cu cent.



III. Pasteurised at 185° F.
2. Bacteria per cu. cent.



IV. Pasteurised at 195° F.
1 Bacterium per cu. cent.

SUMMARY.

1. Milk, as ordinarily delivered at a creamery, may be successfully pasteurized. The milk used in these experiments was largely furnished by patrons who had but ordinary facilities for taking care of it. In the winter, we receive our milk but three times a week ; in summer it is delivered daily.

2. On but two occasions was the acidity of the milk over .2 per cent. The acidity averaged about .17 per cent. There is danger of the milk coagulating when heated, if it contains more than .2 per cent. of acidity.

3. It was noticed that the lots heated from 185 degrees to 195 degrees produced more foam than those heated to the lower temperatures of 140 degrees to 160 degrees. This was most noticeable in the samples heated to 195 degrees. At 185 degrees, the foam was not sufficient to cause much trouble in handling.

4. By cooling the skim-milk with water to a temperature of about 65 degrees immediately after it comes from the separator, we were able to return it to the patrons in excellent condition for feeding, even in hot weather.

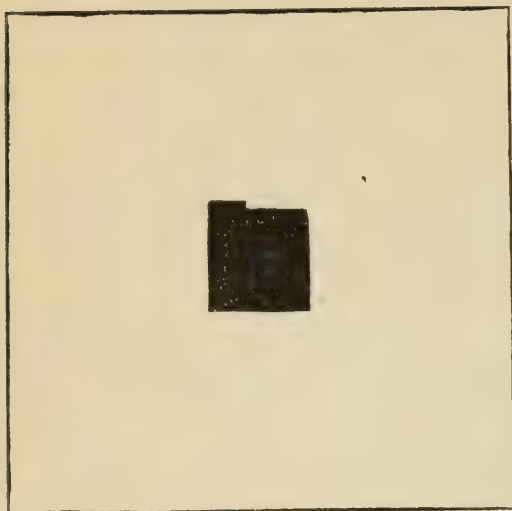
5. The use of 10 to 15 per cent, of culture in the pasteurized cream enabled us to ripen the cream without any difficulty. The culture used was a lactic acid bacillus.

6. Pasteurization of milk at 185 degrees and the use of a pure culture is the best method of securing uniformity, keeping quality, and the mild flavor requisite for export butter.

7. The cooked flavor, which was present in the butter made from milk heated from 185 degrees to 195 degrees, usually disappeared at the end of about two weeks. In one or two lots, heated to 195 degrees, the cooked flavor remained for some time. There is apparently no danger of cooked flavors on butter made from milk pasteurized at 185 degrees, at the end of two weeks, or by the time it would reach the British Markets.

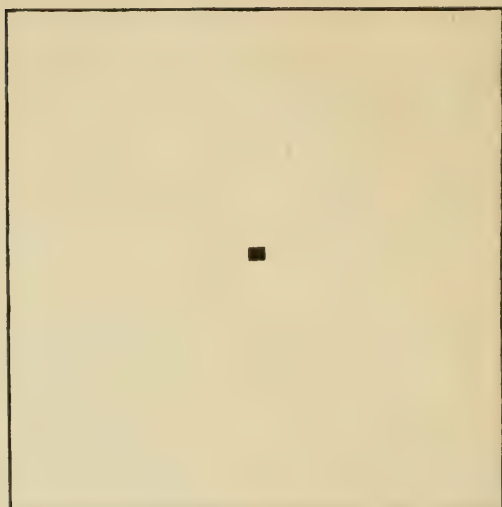
8. The species of bacteria present in the milk when the animals were kept in the stable, were very undesirable. Many putrefactive and fecal bacteria were present, hence the necessity of keeping the stable walls and rafters well cleaned. A good coat of whitewash increases the amount of light, and gives a general clean effect to the stables.

9. The average number of bacteria per c.c. (16 drops) found in milk pasteurized at 140 degrees F. was 631,046, at 160 degrees F. was 12,848, at 185 degrees F. was 81, and at 195 degrees F. was 40. (See diagrams).



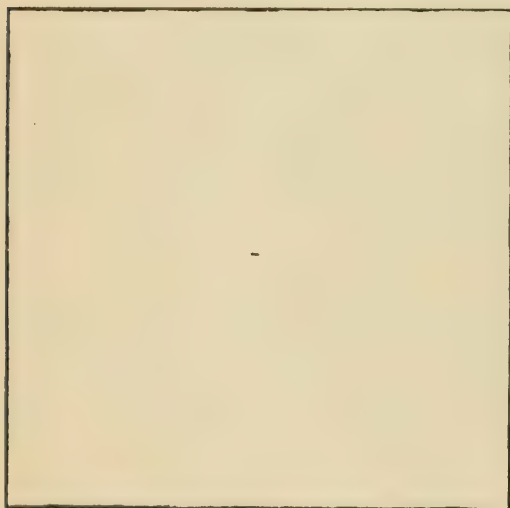
The effect of the continuous pasteurization of milk at 140° to 146° F.

The white square represents the bacterial content of raw milk—average of thirteen days in April, May, June and August. The black space represents the bacterial content of the same samples after continuous pasteurization at 140° to 146° F.



The effect of the continuous pasteurization of milk at 160° to 165° F. (71°-74° C.).

The white square represents the bacterial content of raw milk—average of twenty days in March, April, May, June and August. The black space represents the bacterial content of the same samples after continuous pasteurization at 160°-165° F.



The effect of the continuous pasteurization of milk at 185° F. (85° C.).

The white square represents the bacterial content of raw milk—average of fourteen days in April, May, June and August. The black slit represents the bacterial content of the same sample after pasteurization at 185° F.



The effect of the continuous pasteurization of milk at 195° to 200° F. (91°-93° C.).

The white square represents the bacterial content of raw milk—average of eight days in April and May. The black spot represents the bacterial content of the same samples after continuous pasteurization at 190° to 200° F.

YEAST AND ITS HOUSEHOLD USE.

BY PROF. F. C. HARRISON.

INTRODUCTION.

In the process of bread-making, the management and control of the yeast and its fermentation is usually the least understood part of the operation; and it is owing to mistakes in its treatment that the greater number of failures in bread-making are due. No manipulation of the flour or dough will compensate for weak or badly prepared yeast. The other factors of uncertainty in bread making consist chiefly of insufficient care in kneading and the differences in the quality of flours.

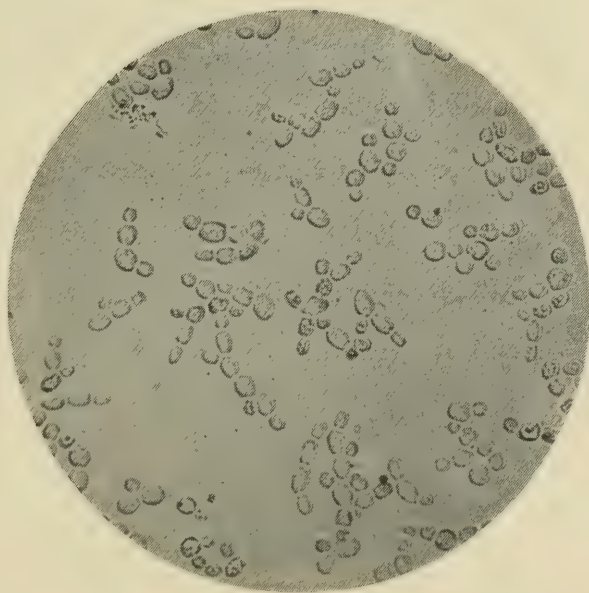


FIG. 1.—Distillery Yeast; from a young culture; magnification, 400 diameters.

This bulletin is written more especially for those who make bread in their own homes; it may also be found helpful to professional bakers who have not had time or opportunity to study the subject. The results of some experiments made in the Bacteriological Department of the Ontario Agricultural College are given.

FERMENTATION. The term "fermentation" is, as a rule, confined to the production of alcohol from liquors and substances containing sugar, but the word is now extended so as to denote many other changes caused by the action of micro-organisms; for instance, the germ causing the souring of milk is often spoken of as the lactic ferment, and the changes which it causes constitute the lactic fermentation; in the same way, the production of vinegar, or acetic acid, is caused by a microbe, and the wine or other substance from which it was made, is said to have undergone acetic fermentation.

In this bulletin, the fermentation of flour is frequently referred to; and by the term it is meant that the sugar contained in the flour is acted upon by a living organism—the yeast plant—and is changed into alcohol and carbonic acid gas, the same gas which is contained in beer and causes it to froth. This gas is formed in the beer by the action of the yeast upon the sugar contained in the malt. The alcohol remains in the beer, but disappears from the bread, being evaporated by the heat during baking.

PUTREFACTION. This term is usually applied to substances which are decomposing and producing a bad odor; when no bad odor is produced in the decomposition the words decaying or rotting are generally used to describe it. There are stricter limitations to the meaning of these words when used in a bacteriological sense, but they need not be given here. It is difficult, if not impossible, to draw any clear distinction between these processes, and that of fermentation. They are all caused by the action of minute vegetable organisms, and all lead to the same result, which is the decomposition of dead organic matter into its chemical constituents, so as to furnish food available for growing plants. This change is constant in the manure applied to land for a coming crop. Every farmer knows that manure must rot, either in the barnyard or in the earth, before the plant can derive any benefit from its application. The crop feeding upon this decaying manure grows up, and is then either eaten or decays where it grows. If it is eaten, a portion of it is excreted as manure and a portion goes to form the flesh of the animal consuming it; the manure undergoes the same process of decay, the flesh gradually wastes during life, and the waste products are thrown off into the air; and when the body dies it decays, forms a portion of the soil, and is again available for plant food.

In order that this process of putrefaction may go on, four things are necessary:

1. The substance to decay.
2. The bacteria to cause decay.
3. A suitable temperature.
4. Moisture.

These are all present in the dough or sponge state of bread-making, as it is desirable to provide the best conditions for the growth of the yeast; and, of course, if other organisms are present they will also grow rapidly and produce sour bread and other defects. Hence great care should be taken to prevent bacteria from gaining access to

the flour, yeast, or dough. It will be shown later on in this article, where bacteria are most likely to be found and how they may be killed or controlled.

BACTERIA. When any dead animal or vegetable substance is left exposed to the air, it immediately commences to decay, if it is at all moist. This change is caused by the growth in it of minute organisms called microbes, micro-organisms, or bacteria. These organisms are the most simple forms of life in the vegetable kingdom. They increase very rapidly by simply dividing into two; and each half then grows and again divides. In some cases, as in the ripening of cream and milk for butter and cheese-making, certain forms of bacteria are necessary in order to obtain good results; but in bread-making, yeast (not a bacterium) is used to ripen the dough, in a manner somewhat similar to that in which a "starter" (or sample of milk containing desirable bacteria) is used in the dairy business to ripen the cream. Other organisms, such as moulds and bacteria, are undesirable and often harmful in bread-making. While there is no way by which, in practice, the flour can be freed from bacteria, yet the yeasts and utensils may be kept comparatively free from them, if the conditions under which organisms grow and increase are understood. Few bacteria will be found where yeast tubs and all utensils are kept perfectly clean and are frequently scalded; but when the yeast is grown in an old tub or is stirred round with dirty hands (which is very frequently done by bakers who think they understand how to make bread, but are puzzled to know why their make is so often sour or dark in color) there is certain to be poor-flavored bread very often.

HISTORICAL. The earliest bread makers used nothing with their crushed grain to make it rise; hence their bread was hard and solid, and so had to be in thin cakes. Ching NOUNG, the successor of Fohi, is reputed to have been the first who taught men the art of husbandry and the method of making bread from wheat, and wine from rice. Fermentation was made use of at the time of Lot, for we read that "He did make them a feast and did bake unleavened bread." Baking reached a high state of perfection in Egypt. It became a profession at Rome, 170 B.C. After the conquest of Macedonia in 148 B.C., numbers of Greek bakers came to Rome, secured special privileges, and soon obtained a monopoly. Later, a special magistrate was appointed to superintend the public bakeries. Pliny states that the Romans used a leaven composed of grape juice and millet which kept for a year. This leaven doubtless contained a large quantity of yeast, as yeast is always found upon the surface of ripe grapes. From Rome the method of bread making spread gradually with civilization; and at present, fermented bread is in general use, except in a few of the northern countries of Europe, and in other places distant from civilization.

THE YEAST PLANT.

Yeast belongs to that division of the vegetable kingdom known as *Fungi*,—a class or group of plants which do not possess any chloro-

phyl (or green coloring matter), and which therefore must obtain their nourishment from organic matter.

GROWTH. The yeast plant consists of a single cell, which, when it reaches a certain size and is kept under suitable conditions, sends out a bud from some part of its surface, which gradually increases in size. This bud may or may not remain attached to the old cell. If it does so and if the old cell continues to send off more buds, a mass of cells is soon formed ; but if each cell as it grows produces a bud, a long chain of cells is formed

SPORES. Under certain conditions, (moist surface, plenty of air, favorable temperature, and vigorous cells), small round bodies, from two to eight in number, are formed inside the old cell, which bodies are called spores. (See Fig. 2.) These may remain dormant



FIG. 2.—A wine yeast shewing spore formation ; magnification, 1,000 diameters.
From 2 to 4 spores may be seen in most of the cells.

for a considerable length of time, but will germinate when placed in suitable food. They are usually more resistant than the cells in a vegetative condition. The ordinary yeast cell lives for a considerable length of time when it is kept dry.

FUNCTION. Yeast is mixed with the flour to cause the dough to rise, and by so doing to make the bread more palatable and digestible ; and the rising is caused by the separation of the particles of the flour by the gas formed as a result of the action of the yeast upon the sugar contained in the flour, and it enables the digestive fluids to act more readily upon them ; the yeast also acts to a slight extent upon the gluten of the flour, causing it become softer and less like rubber. Yeast also gives to the bread a distinct flavor which cannot be obtained in any other way.

VARIETIES. There are a large number of varieties of yeast, and, as in the case with other plants, some varieties are more suitable for use than others. Yeasts of different varieties are used in the manufacture of fermented liquors, such as beer, whisky, wine, cider, etc. No doubt any of the yeasts would cause fermentation in flour to a greater or less extent during the process of bread making, but some would require twelve to fourteen hours to cause the dough to rise to the same extent as another would in seven or eight hours. Many kinds produce a bad flavor; others a bad color in the loaf; and for these reasons, it will be seen that it is a matter of importance to use only a yeast which is suitable for bread making. This is specially important for persons who grow their own yeast; and those who do so, may select from the various brands upon the market, by making small sponges with each kind of yeast, being careful to put into the sponge equal quantities of flour, water, and yeast. Of the different lots, that which gives the best fermentation is selected; or bread may be made from each and the results compared, in which case the yeast giving the best results is used to start the brew with.

BAKERS' YEAST.

Yeast is sold for bakers' use in three forms:

1. COMPRESSED YEAST. This yeast is put up in the form of moist cakes, and should consist entirely of yeast cells. It is usually a distillery yeast (see Fig. 1), most of the moisture having been pressed out by a mechanical process. There are yeast factories where yeast is made as the chief product, the fermented liquor being only a secondary one, and these factories should produce a much purer yeast than they usually do. The compressed yeast examined in our laboratory has invariably been more contaminated by moulds and bacteria than the yeast from breweries and distilleries.

The term "*purity*" of yeast is used here in a biological sense, and does not refer to any chemical or other substance, such as starch or corn meal, which are frequently mixed with the dried yeasts.

The compressed moist yeast keeps, as a rule, only for a few days. Some of the manufacturers state, however, that it will keep for a month or so, if placed under cold water so as to be kept from the air. This form of yeast generally gives the best results, and it is more easily used than other forms; but, owing to its poor keeping qualities, it is not suited to the use of persons living in the country. In towns it is usually distributed by the manufacturers every two or three days. When fresh it should have a pleasant, wine-like smell, and should break with a sharp grain, and not be at all sticky or putty-like.

2. DRIED YEAST. The dried yeast cake is the best form in which yeast can be obtained for the use of those who live in the country or in places where it may be necessary to keep the yeast for some

length of time. Being dry the cakes cannot decay, as bacteria are unable to grow where moisture is absent; but if the cakes are kept too long, the yeast will lose its vitality and die.

Dry yeast is often sold in the form of a powder, being mixed with the grains and hops used in its cultivation in the yeast factory.

3. BREWERY, OR LIQUID YEAST. Yeast is often sold by brewers to local bakers. It grows in the fermenting vats of the brewery, and is either a "top fermentation yeast," which rises to the top of the vat, or a "bottom fermentation" yeast, which sinks to the bottom. In the former case, the yeast which is first skimmed off should not be used for bread-making, as it always contains a large quantity of impurities, such as pieces of dirt, dust and bacteria; the yeast collected at the middle of the fermenting periods is the more vigorous, and that which is obtained last is often weak, and does not always give satisfactory results. Brewers' yeast sometimes gives a bitter flavor to bread; but it is said that this may be got rid of by washing the yeast in cold water and allowing it to settle, the water being then poured off.

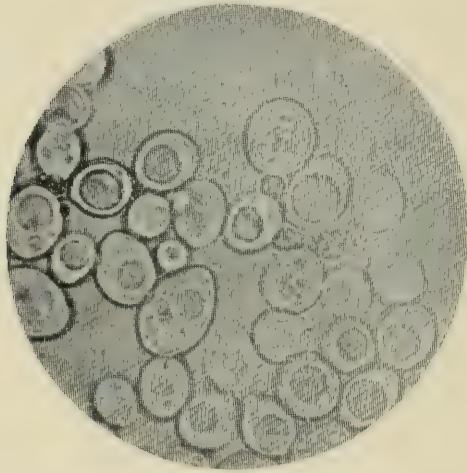


FIG. 3.—Fresh Brewery Yeast ;
magnification, 1,000 diameters.

It is probable that those who use large quantities of yeast will find it more economical to grow their own, especially if a man is employed who thoroughly understands its management; the expense will be far less than if the yeast is purchased, the cost of the materials necessary for the growth of a pound of yeast, being much less than that of a pound of compressed yeast; and by the use of the hops and malt used in the yeast brew, a characteristic nutty flavor is given to the bread, which cannot be produced in any other way. In bakeries where various kinds of bread are made, both kinds of yeast may advantageously be used; but unless the principles of yeast growing are thoroughly understood, it will not be advisable to make experiments where large quantities of bread are made.

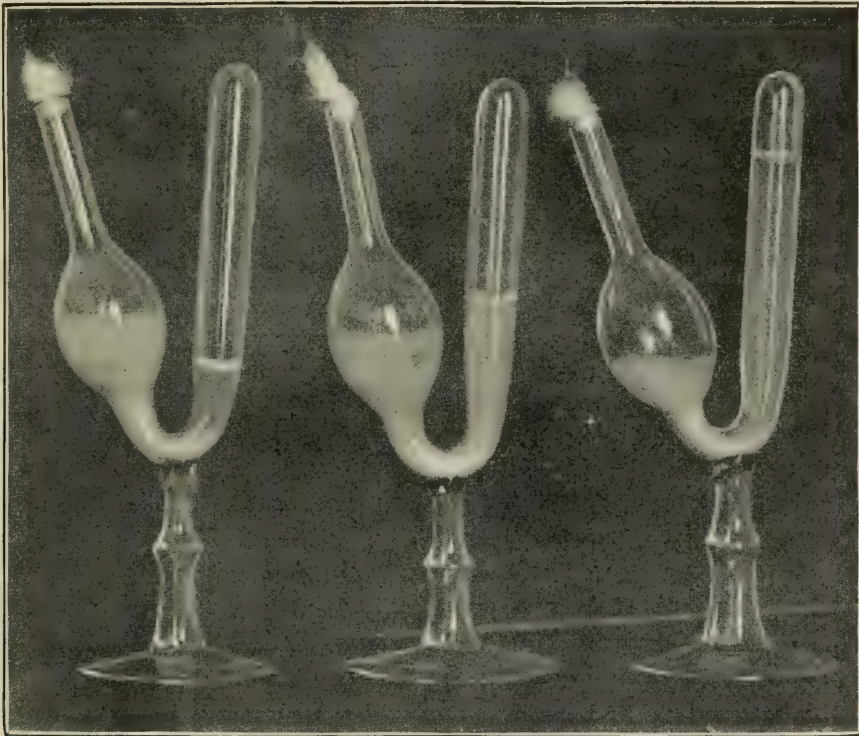
LABORATORY TESTS.

YEASTS USED IN LABORATORY EXPERIMENTS. Yeasts were obtained from twenty-eight sources and tested for fermentative power: From breweries, eight, which had been used in making ale.

From breweries, three, which had been used in making lager beer.

From whiskey distilleries, four.

Nine, which had been put upon the market for bread-making purposes.



1

2

3

FIG. 4.—Fermentation tubes containing flour and water—

1. With addition of a distillery yeast.

2. “ “ brewery yeast,

3. “ “ dried cake yeast.

Note, in the right arms of the tubes, that there is more gas in 1 than in the others, shewing the more energetic working of the distillery yeast. For the same reason there is more gas in 2 than in 3.

One, which was isolated in making a bacteriological examination of a sample of malt extract.

Two obtained from bakers who grew their own yeast.

One obtained in making a bacteriological examination of Stilton cheese.

In the test made for rapidity of fermentation, there were three which gave a much more rapid fermentation than any of the others, and which were considered to be equal. One of these was from a

distillery, one from a compressed yeast (sold for bread-making and ordinarily produced at a distillery), and the third from a home-grown yeast which had been started with a compressed distillery yeast.

The beer yeasts in several instances gave better results than yeasts sold specially for bread-making. Some of the latter gave very poor results, indeed, showing that sufficient care had not been taken when starting the growth of the yeast at the factory to obtain one which was well adapted to bread-making. The experiments show the superiority of distillery yeasts over brewery yeasts for the fermentation of flour. They seem to act upon the starch of the flour more energetically than do the beer yeasts.

In experiments made on mixtures of flour and water in fermentation tubes, the distillery yeasts always produced considerably more gas than did the other kinds; they also produced the gas more quickly. (See Fig. 4.)

ACTION OF YEAST.

The most striking change in dough after the addition of good yeast is the rising or swelling of the mass. This is caused by the action of the yeast upon the sugar which is present in the flour, and to a slight extent upon the starch, which has been changed into a kind of sugar called dextrin, chiefly by the diastase in the flour. These sugars are converted into alcohol and carbonic acid gas. The alcohol may usually be plainly smelt by making an opening in the dough at the end of the doughing stage; but it is evaporated on heating the dough in the oven during the process of baking. Small quantities of it, however, are said to be retained in the bread. The gas which is formed in the dough during fermentation is unable to get away, owing to the sticky nature of the flour. It is held in small bubbles, the form of which can be seen on looking at a piece of bread, the small holes representing the spaces occupied by the gas bubbles in the dough. The effect of the heat in the oven upon these bubbles is to cause them to expand, and thus force the particles of flour farther apart, so that the loaf when baked is much larger than the piece of dough before baking.

Other changes occur which are not clearly understood, and which result in the production of "grain" or texture in the loaf. If a dough is set and a portion is taken off and baked at the end of, say six hours, and other portions taken at eight and ten hours, respectively, those which have been taken too early will not produce bread of so good texture, flavor, or color as those taken later; but if any portions are left too long the bread made from these will be crumbly and brittle, owing to the fact that the gluten has been stretched so much by the gas that it is unable to hold the particles firmly together.

PROPERTIES OF YEAST.

FERMENTATIVE POWER. The most important function of yeast is to form gas and thus raise the dough; and some yeasts form very

much more gas in a given time than others. Figure 4 shows the effect of different yeasts upon equal quantities of the same grade of flour mixed with the same amount of water and kept under the same conditions during fermentation.

The strength of any yeast may be much lessened by improper treatment before mixing with the flour. This is most frequently seen when home-brewed yeasts are used; and the yeast is then said to have run out or lost strength. This is usually due to the fact that it has not had a sufficient quantity of suitable food, or has been kept at too high a temperature during its growth in the yeast tub. In two samples of yeast sold for bread-making in the form of dried cakes, composed of yeast cells and corn meal, no living yeast could be found. It had most likely died from being kept too long without moisture.

The form which the yeast is in when added to the flour determines very largely the rapidity of fermentation. In dried cakes the yeast is usually in a dormant condition, often containing spores; and, as compared with compressed yeast, it contains fewer cells present in the same quantity of material. For these reasons, dried yeasts should be soaked in warm water, in which a small quantity of sugar has been dissolved, to act as food for the cells. Compressed yeast being fresh, the cells are in an active condition, and commence to grow and produce gas as soon as mixed with the dough.

RELATIONS TO TEMPERATURE. Different temperatures have as much effect upon the growth of the yeast plant as upon that of other plants. A temperature between 75° and 90° F. seems to be the most favorable for gas production in sponge or dough; but the ferment, or yeast brew, must not be kept at a high temperature, or the yeast will become weak,—just as plants in a hot-house, growing at ordinary temperatures, grow more rapidly and flower more abundantly when brought into a higher temperature for a portion of their life, yet gradually weaken if kept there too long. The temperature at which the yeast plant is grown should always be somewhat lower than that at which the sponge is set. Although the above figures are given as being near the limits for good fermentation, still the temperature of the flour and the water before being mixed must always be taken into account, also the time of year and the temperature of the air; as in hot weather fermentation will proceed more quickly than in cold and *vice versâ*. In winter, when the flour is cold, the setting temperature may require to be as high as 95° F.; whilst in summer, the flour being warm, the temperature may require to be brought down as low as 70° F. A thermometer should always be used; and the temperatures should be correctly taken. This is just as important in bread-making as in butter-making and cheese-making.

PURITY. The next most important property of yeast is that it be pure, that is, free from moulds and bacteria, as it is to the presence of these organisms that most of the bad flavors and disappointing results are due. It is seldom or never that any bread-making yeasts are met with which are not contaminated to a greater or less extent. This has

been noticed especially in our experiments with the compressed yeasts, of which all the samples examined contained an enormous number of moulds (Fig. 5) and bacteria; and while it is often possible to have a yeast contaminated and still obtain good bread, yet it is almost certain that if the yeast cells become weakened from any cause, the bacteria will increase with such rapidity that bad bread will be the result; but when the yeast is strong and vigorous, it holds many bacteria in

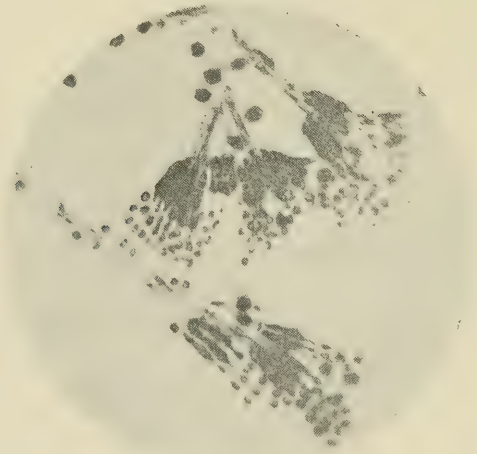


FIG 5.—A common mould (*Penicillium glaucum*), often found in dried yeast cakes. Magnification, 500 diameters.

check and prevents the injury which would be caused by their growth.

An investigation into the cause of ropy bread, conducted at the Wisconsin Experiment Station, proved that bread which became slimy after baking had been made so by the action upon it of a certain germ—*Bacillus mesentericus panis viscosi* (Fig. 6)—which is frequently found in the earth. It probably gained access to the bread in the potatoes used in making the yeast, a point which will be referred to later on.

Sour bread, which is of frequent occurrence, is also due to the presence of micro-organisms in the dough. It is disputed whether these organisms produce butyric, lactic, or acetic acid; but, for practical purposes, it is sufficient to know that germs are the cause of the souring. The germs may be in the flour, the yeast, or the cracks and corners of the kneading trough, or of other utensils which have not been properly cleansed. It is not possible to free the flour from germs; but experiments have shown that the high grades of flour are almost free from bacteria, and the number of germs increases as the quality of the flour decreases. The yeast may be kept almost entirely pure by proper management; and the utensils may be kept free from impurities by washing and scalding them just as thoroughly as dairy utensils, and with the same object, viz., to kill all germ life.

METHODS OF YEAST CULTIVATION.

It is not necessary in this bulletin to go into the manufacture of pressed and dried yeasts, as they are usually prepared upon a large scale and require the employment of a large plant and building. The chief points to be remembered in making a yeast brew are—

1. To start with a pure and vigorous yeast.
2. To maintain a suitable and even temperature at all times.
3. To practise the greatest cleanliness in order to avoid the contamination of the yeast by bacteria.

The number of receipts given for making yeast ferments is very large; and, as the proportions of the constituents differ so greatly, it is evident that they cannot all be correct. Potatoes, flour, malt, sugar, and rice are all recommended; and any of them may be suitable under certain conditions. Those most easily obtainable for use in the home are potatoes and flour. Rice may be used, if potatoes are scarce;

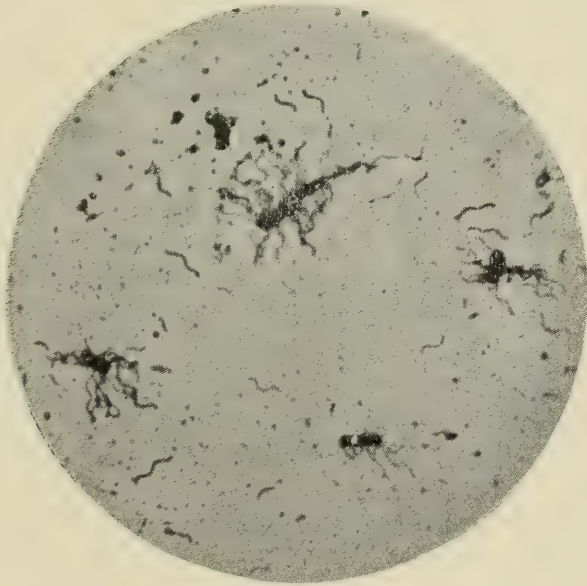


FIG. 6.—*Bacillus mesentericus panis viscosi*.
Magnification, 1,000 diameters.
This germ causes slimy bread.

but it is said to lessen the fermentative action of the yeast. Potatoes are most generally used; and, as a rule, they give very satisfactory results, when care is taken in their preparation. They appear to have a very stimulating action upon the fermentative power of the yeast; and one set of experiments made in the laboratory showed that yeast grown in the water in which potatoes had been boiled and then mashed, gave a quicker and more vigorous fermentation than that caused by yeast grown in hopped malt extract, which is usually supposed to be the best medium in which to grow yeast. The

disadvantage in connection with potatoes is that they have been in contact with the earth and possess so many cracks and eyes that they are difficult to free from bacteria always present in large numbers in the earth, and for this reason many large bakers in English towns have given up using them. If potatoes are used, they should be most thoroughly scrubbed in several changes of water, and then boiled or steamed till cooked. It is a common practice to mash the potatoes up with the skins. This is a mistake, and may cause trouble for the following reasons: The boiling will not kill many of the spores of bacteria which are upon the skin; and if the skin containing them is mixed up with the ferment, the spores will commence to grow, and, as has been shown elsewhere, may give bad results. Further, the substance just under the skin consists partly of *solanin*, which, when the potato cools, gives in many cases a rank and bitter taste that may slightly taint the bread. For these reasons, the skins should be thrown away. It is better to boil the potatoes again after peeling them, as by so doing the starch, which, in its raw state, is less capable of acting as a yeast food, may be gelatinised as much as possible.

When flour is used, it is better to cook it than to use it raw, for the same reasons as those for which the potato is cooked, viz. to destroy germ life and to gelatinise the starch. It may easily be cooked by mixing with cold water and bringing to the boil,—the result of which should be a thin paste. If only the highest grades of flour are used, it will be an advantage to use a little sugar. Raw flour is frequently added to cooked potatoes, cooked flour, and malt; but raw flour contains small quantities of diastase, the amount decreasing as the grade of the flour improves; and, as already intimated, diastase has the power of changing starch into sugar. Now, it has already been stated that the lower grades of flour, which contain the largest quantity of diastase, also contain the largest number of bacteria; and, for this reason, it is questionable whether raw flour should be added to a properly gelatinised substance. The starch has to be gelatinised, because in its raw condition it is insoluble, and so cannot be acted upon by the yeast; but when it is gelatinised, the insoluble outer covering of the starch cell is ruptured, and the soluble portion is then available as yeast food.

In places where malt can be obtained it will be found a good substitute for potatoes. Yeast grows exceedingly well in malt extract, and it is easily prepared for use. To make the malt extract, the raw malt must first be coarsely ground and then “mashed” in the same manner as is done in breweries. On no account should the malt be boiled, as is sometimes done, because the boiling destroys its diastatic power. Malt contains starch and diastase and also sugar. The mashing is performed to cause the diastase to act upon the starch and to convert it into sugar. High heat, accompanied by moisture, will destroy the diastase, and then a great portion of the contents of the malt will be destroyed. Badly prepared malt, that is, malt which has been prepared from grains that have not germinated sufficiently or that have been heated too highly in the early drying stages, does not

contain much diastase. If heated too highly, the malt will be of a dark color. Pale malts have, as a rule, a higher diastase power than dark malts.

“Mashing” consists in keeping the malt mixed with water at a temperature not exceeding 140° F. for a couple of hours. A slightly higher temperature will destroy the diastase, and a much lower one will retard its action. In two hours the grains may be strained off, after having been well stirred up. Malt extract is, however, usually made up with hops, in order to obtain the hop extract.

PREPARATION AND USE OF HOPS.

In the making of beer, hops are used for three purposes: First, they act as an antiseptic; second, they clear the worts; third, they give a characteristic flavor to the beer. The baker does not, as a rule, wish to flavor his bread with hops, neither does he wish to clarify his ferment, but he does need to have in his ferment an antiseptic; that is, a substance which will prevent bacteria from growing in it; but, while it hinders the growth of the bacteria, it must not affect the yeast in the same manner. The resins contained in hops, and which appear in the form of a fine yellow powder at the base of the bracts of the hop flower, possess the required properties, and have no injurious effects upon those consuming the bread, which is more than can be said of most antiseptics. In order to extract this substance from the hops, it is necessary to heat them in water, but not boil them, at least, not for any length of time, as this will extract a strong, bitter principle, which may cause an unpleasant flavor in the bread. The hops, with the water, should be heated to the boiling point, and there maintained at a slightly lower temperature for about two hours, allowed to stand for a short time, and then strained off. The resulting hop extract may then be mixed with the malt extract, if the latter is sufficiently strong; but the quickest way is to prepare the hop extract, strain it, and cool it to between 130° and 140° F.; then add the malt, and proceed as shown in the previous paragraph. After the mixture has been properly mashed, the whole is boiled for a few minutes in order to kill the germs that may be present; and it is then cooled down to 86° F. as quickly as possible and the yeast added.

The proportion of hops recommended in the various receipts range from 1 oz. of hops in 4 gallons of water to $1\frac{1}{2}$ oz. of hops in 2 gallons of water, or more than half as much again as the former quantity. In order to ascertain the amount of hops which was really necessary, we conducted a large number of experiments on different species of bacteria, using different strengths of hop extract; and the results showed that for practical purposes, 1 oz. of hops in two gallons of water gave as good results as a larger quantity. It must, however, be remembered that the action of the hops depends a great deal upon the stage at which they have been picked, and how they have been grown, dried, and stored. If picked when too green, or if too highly heated in drying, they will not contain as much resin as if properly prepared; and

if not sufficiently dried, they will become musty and impart that flavor to the bread.

No receipts using potatoes with hops were seen in any books, though it is possible that such may be in use. In the laboratory experiments, hopped potato ferment gave apparently good results on a small scale; and there seems to be no reason why such a ferment should not be equally good on a large scale. Its advantage is obvious when we take into account what has been already said about potatoes. The germ *Bacillus mesentericus* (Fig. 6), mentioned in connection with ropy bread, was one of those upon which the hop extracts were tried, and it was shown that they had a great antiseptic power against it.

An addition of salt to the brew is often recommended; but it serves no really good purpose. It has a retarding effect upon the growth of the yeast and very little upon that of bacteria. It should not be added to the flour until the doughing stage. If hops are not obtainable, small quantities of salt, not exceeding $\frac{1}{4}$ of an ounce to the gallon, may be used and will act as a slight check to bacterial growth.

RECEIPTS FOR BREWS, OR FERMENTS.

It is not possible to give any one or even two or three receipts for brews or ferments which will be suitable under all conditions; but for home baking, the following are submitted as examples; and, with a good yeast, they will give excellent results:

No. 1.—1 lb. potatoes.
 $\frac{1}{2}$ oz. hops.
 1 gall. water.

No. 2.— $\frac{1}{2}$ lb. malt.
 $\frac{1}{2}$ oz. hops.
 1 gall. water.

The important point in making a good brew is to boil it before adding the yeast, in order to make it as sterile as possible; and when it is cooled to 75° or 80° F., add the yeast or a portion of the old brew. The vessel in which the ferment is kept should be of such shape that as large a surface as possible of the liquid will be exposed to the air; and the mixture, both before and after the yeast is added to it, should be frequently stirred in order to admit a plentiful supply of air, fresh air having a great effect in increasing the activity of the yeast. The vessel should be supplied with a lid, instead of the usual empty sack which does service as such; a stirrer should be kept in the vessel; and it should be kept for the purpose of stirring only. The stirring should never be done with the hands, as is frequently the case.

DIGESTIBILITY OF YEAST-FERMENTED BREAD.

An important point in bread-making is the effect of the process upon the digestibility of the product. There are ways of making the bread to rise other than by the use of yeast, the most common way being by the use of baking powder and water, or by baking soda and buttermilk or sour milk. These powders are composed of chemical substances,

the former containing sodium bi-carbonate and some acid (usually tartaric acid or calcium phosphate); the latter consists of sodium bi-carbonate alone, the acid being furnished by the lactic acid in the sour milk. Sodium bi-carbonate, when moistened and mixed with an acid, forms a gas, carbon dioxide, which is the same gas as is formed by the yeast cell; but besides the gas there are other substances formed which remain in the bread and which may or may not be injurious, according to the nature of the acid used, and the proportions of the chemicals to one another. If hydrochloric acid is used, as in the case of the manufacture of aerated bread, then only the substances sodium chloride, or common salt, and the gas are formed, if the proportions are correct; but when tartaric or lactic acid is used, a substance is formed, called sodium carbonate, which remains in the bread and is consumed,—which substance has been condemned as injurious to the health when used as a preservative in milk or butter. It is one of the most common remedies in cases of acidity of the stomach and for this reason alone cannot be considered a desirable substance for a healthy person. Every one is familiar with the disagreeable taste and yellowish brown color given to cake when too much soda is used, both the color and taste being due to sodium carbonate which has not been neutralized. But apart from this reason, the flour in bread or cakes so made, is not so digestible as that from yeast-fermented bread; because the starch and other substances are not acted upon by the chemicals in the same manner that they are when subjected to the prolonged fermentative action of the yeast and the diastase contained in the flour; the gluten does not undergo the softening changes that it does under the action of the yeast; and the particles of flour are not so finely divided. Consequently baking-powder cakes are not so light and spongy as bread made in the usual way; and for this reason they are not so readily digested, the coarse particles not offering so large a surface to the action of the digestive fluids as the finely divided particles of well fermented bread.

AERATED BREAD. The aerated bread referred to above was first made by Dr. Daughlish. The process adopted by him consists of kneading the dough by mechanical means in an air-tight metal compartment, the dough being thoroughly mixed with carbonic acid gas under pressure while in the kneading trough. The dough is put into the oven immediately after it has been kneaded and rises during the process of baking. The chief advantage of this method is that time is saved, as it is not necessary to wait for the prolonged fermentation of the yeast; and no opportunity is given for undesirable germs to grow and cause sour or bad-flavored bread. Aerated bread is very light, and a uniform quality and good color can always be produced; but it has a raw insipid flavor, which causes the consumer to tire of it.

SALT BREAD. There is another method of making risen bread, that is, the method called salt-rising. It is the result of a spontaneous fermentation, and it is therefore a matter of chance whether good bread will be produced, although in places where such bread has been

made for some time there is less likelihood of failure, as the utensils and air of the rooms in which the bread is made contain large numbers of the desirable germs.

EFFECT OF BAKING ON DIGESTIBILITY. The action of the heat during baking has a great effect upon the ease with which the bread is digested. The outside of the loaf may be heated to about four hundred degrees, thus causing it to become brown. The temperature of the interior of the loaf most probably does not exceed that of boiling water. The highly heated starch on the exterior is converted into dextrin, which is a kind of a sugar and is entirely digestible; and the fact that this dextrin or sugary substance is thus formed is taken advantage of when making fancy breads that are glazed. The glaze is formed by turning a jet of steam into the oven for a moment while the loaves are hot. The steam combines with the dextrin and forms dextrose, which is the sticky, shiny substance seen on the surface of the loaf.

NOTE.—Illustrations 1, 2, 3 and 5 from Doyen and Roussell's *Atlas de Bacteriologie*.

Ontario Agricultural College and Experimental Farm.

VENTILATION OF FARM STABLES AND DWELLINGS.

BY PROF. J. B. REYNOLDS.

For people who live in house, ventilation is one of the many problems that have to be solved. Abundance of sunlight and of fresh pure air is the basis of cure that has been adopted at modern consumptive sanitariums. The prevalence of tuberculosis among both cattle and men is to a considerable extent due to close confinement, for longer or shorter periods, in ill-ventilated and badly lighted rooms. Dark, close basement stables for cattle, and tightly-bottled-up dwellings for men, women, and children, are too often found in this and other countries.

Ventilation is a matter more of accident than of plan in most of our houses and stables. As a consequence, the inmates are breathing the same air over and over again. This would be bad enough if every inmate of the house were perfectly healthy, for the products of respiration, even of a healthy animal, are a mild poison, which are, however, prevented from doing much harm by being more or less diluted. But when we remember not only that the expired breath of an unhealthy animal contains the usual constituent of carbonic acid, but that its presence is very likely to infect the air with the germs of disease as well, the necessity for frequently changing the air of occupied rooms is quite apparent.

In warm seasons, and in warm climates, the problem of ventilation is a comparatively easy one. We have only to throw open our dwellings to the action of the breeze, and the air is continuously changed. But in the wintry season, and in rigorous climates, the question is one of considerable complexity; for along with the demand for fresh air comes another more immediately urgent—the demand for warmth. In cold weather, these two requirements must necessarily conflict, and the one need is satisfied at the expense of the other. That being the case, we manage to have the more urgent need satisfied, and neglect the remoter necessity. We are more sensitive to cold than to impure air; and in order to secure a proper degree of warmth without too great cost, we are content to ignore the fact that we are breathing impurities.

During the greater part of the year in this country, the question of ventilation involves the question of temperature. We have not only to make provision for bringing fresh air into our dwellings, but we must warm it artificially after it is introduced. Therefore, ventilation, particularly for dwellings, is doubly expensive. We have to provide contrivances for renewing the air in houses and stables. That is one item of expense. In stables we have to guard against too great a reduction of temperature, and hence a system of ventilation in stables requires either careful watching or special appliances for warming the air. In houses, we generally expect to warm the incoming air by the consumption of a little more fuel.

That is the second item of expense. It remains for us, therefore, to sit down and count the cost, whether we will put up with the dangers and inconveniences and discomforts of bad ventilation, or pay the charges for introducing and keeping up a system of changing and purifying the air that we breathe in our dwellings, or that the animals under our charge breathe in their stables.

WHAT IS VENTILATION? Theoretically, perfect ventilation consists in removing the unwholesome products that are diffused through the air of occupied rooms, as rapidly as these products are formed. But perfect ventilation exists only in theory. Practically, we are satisfied if we can remove a certain portion of these products,—carbonic acid gas and moisture from the lungs,—and dilute the remainder to a definite standard, by mixing with pure fresh air. An ordinary test of a system of ventilation, is to determine the percentage of carbonic acid gas present in the



“Light and Airy.”

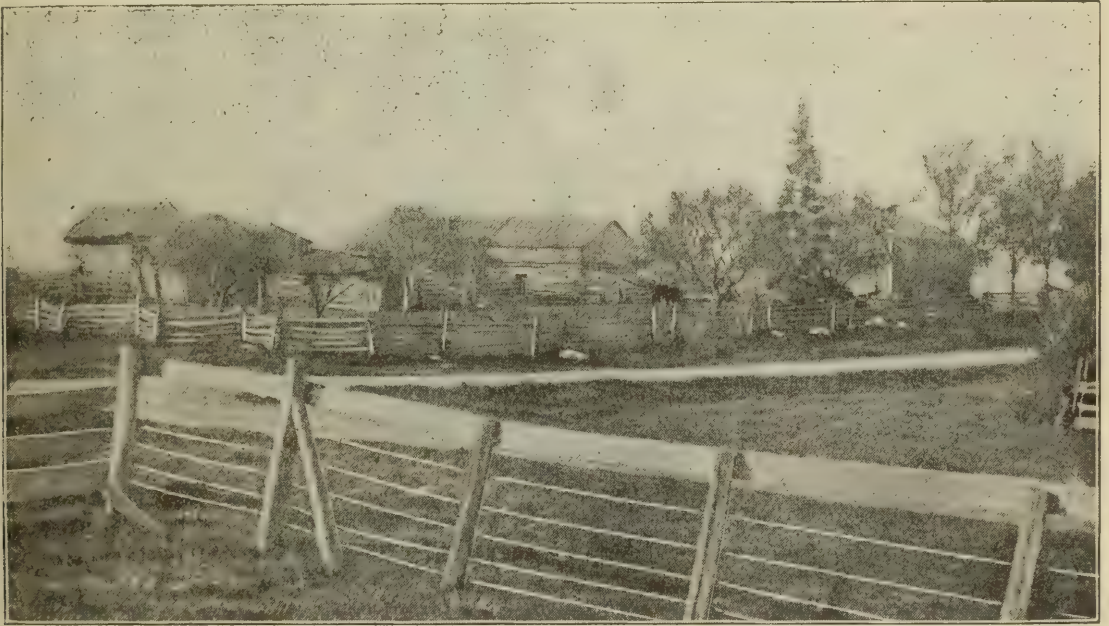
air of the room, and compare this with the amount of the same constituent that is found in pure air. In any case, ventilation consists in removing certain portions of the air, and continually introducing fresh air. The rate at which this is done will fix the degree of completeness of the ventilating arrangements. For this constant removal and introduction of fresh air, certain forces operate, which forces depend upon certain physical principles. It is important that every man who is thinking of ventilating his house or stables, should understand these principles, in order that he may adapt the suggestions that are made in this pamphlet to suit his own circumstances.

THE PROBLEMS IN VENTILATION. The object to be gained in ventilation is the maximum quantity of fresh air. But with the introduction into a room of large quantities of fresh and generally cold air, we must

guard against the possible consequences, viz., *drafts, cold, and dripping* or condensation of moisture within the room. The problems then are :

- (1) To find a force that will keep the air in motion : removing foul air and bringing in fresh ;
- (2) To introduce and distribute the air so as to avoid drafts ;
- (3) To prevent the ventilated room from becoming too cold ;
- (4) To prevent condensation of moisture in the room.

NATURAL AIDS TO VENTILATION. Under the first of the above mentioned heads, there are certain natural forces or tendencies in the gases of which air is composed, that aid in ventilating a room or stable. The first of these we shall consider under the head of "Gravity."



Built in the days when the question was, not how to let fresh air in, but how to keep it out.

When the air is warmed, it has a tendency to expand, and will do so if allowed. The result of the expansion is that it becomes lighter, bulk for bulk, than the cooler air. The warm air, as a consequence of its lighter weight, is displaced by the cooler air, and driven upward, on the principle that heavy bodies sink when immersed in fluids that are lighter than themselves. A stone when thrown on the top of water sinks to the bottom on exactly the same principle that cold air flows in underneath or falls down through warm air and forces the latter upward. This sinking of cold air and rising of warm air is called *convection*, and this convectional movement of air is one of the forces, if we may so speak, that operate in ventilating buildings. In an occupied room or stable, the heat from the bodies of the occupants warms the air and produces the upward tendency. If this tendency is encouraged so far as to allow the rising air to escape altogether, and if at the same time provision is made for the cooler fresh air to find its way into the room or stable, we have ventila-

Whether or not this convectional movement is a sufficient force to satisfy satisfactory ventilation, is a question to be considered later.

The second of these natural aids to ventilation is "Diffusion."

The air that we take into the lungs may contain but little water-vapor; and, if pure, it contains a very small percentage of carbonic acid gas. The latter is a chemical compound of carbon and oxygen. It exists in the free atmosphere in very small quantities,—the average amount of which has been estimated at $3\frac{1}{2}$ volumes of carbonic acid gas in 10,000 volumes of air. On the other hand, the breath expired from the lungs is saturated with moisture, and contains between 4 per cent. and 5 per cent. of carbonic acid gas; or, to state it in the same form as above, in 10,000 volumes of expired air there are about 430 volumes of carbonic acid gas. The problem of ventilation is to prevent these two products—moisture and carbonic acid gas—from accumulating in excess within the occupied spaces. Aqueous vapor, at the same temperature and pressure, is lighter than air; carbonic acid gas is considerably heavier. It might be supposed, therefore, that when these products are emitted from the lungs, the aqueous vapor would raise to the ceiling, and the carbonic acid gas settle to the floor. There is a tendency to this movement; but, at the same time, a process goes on which is equally as effective as the force of gravity. This process is known as *diffusion*. A simple illustration of diffusion may be seen by putting a few drops of milk into a glass of clear water. Soon the milk is seen to diffuse through the water, giving a uniform whitish shade to the whole. The same thing goes on with the aqueous vapor and carbonic acid gas. Instead of separating completely according to density, from the air of the room, these products diffuse throughout the whole room; so that wherever the foul air opening is placed, it will find almost uniform proportions of the products that ventilation is required to remove. If any difference, however, exists in the distribution of these gases, the excess of carbonic acid will be found at the floor; while that of water-vapor will be found at the ceiling.

Another aspect of diffusion is the movement of gases through porous walls. Suppose that the air of a room becomes overcharged with carbonic acid gas, and at the same time robbed of its oxygen; then the carbonic acid will diffuse outward through the plaster of the walls, and through the brick or between the clapboards; and the oxygen from the outside will in the same manner diffuse into the room. So that a natural ventilation proceeds at all times, even if the room appears perfectly air-tight. This natural ventilation is, of course, most rapid in rooms that have the greatest amount of wall-space exposed to the free outside atmosphere.

A third natural aid to ventilation is the *wind*. When the fresh air inlets are on the windward side of the building, there will be no question about plenty of ventilation. But when the wind blows from the side opposite the inlets, there is little or no ventilation. To make free use of the wind, therefore, it is necessary, either to have *inlets at all sides* of the buildings, or to have inlets that *always face the wind*. These two methods will be illustrated in detail in discussing particular systems of ventilation.

Under the second head, namely, distribution of fresh air in the stable, it is necessary to admit the air directly into the stable through a *number of small openings* rather than one large opening. How this may be done is shown in the plans of ventilation given below.

The third point, namely, temperature, constitutes a great difficulty in the ventilation of stables in winter. To introduce fresh cold air into a stable at any considerable rate and to draw off warmer air, necessarily cools the stable, and may cool it below the point of comfort and safety. Without artificial heating, the only safeguards against a temperature too low are: (1) A crowded stable, in which the animal heat given off is sufficient to warm large quantities of incoming air; hence the amount of ventilation may be, as it should be, in proportion to the number of animals in the stable. (2) A naturally warm, tight stable, which allows but little cold or drafts to enter the stable, other than by ventilating arrangements. (3) Shut-offs in the inlet and outlet pipes, so that the amount of ventilation can be controlled according to the temperature of the incoming air, the principle being to get as much fresh air as is consistent with a proper stable temperature,—between 35° and 45° . (4) A sub-earth duct, by means of which the fresh air, before being admitted to the stable, is carried for some distance through an underground pipe, 6 feet deep or more. The earth-temperature at that depth being much higher than that of the outside air, the air is warmed in passing through the duct, and enters the stable at a much higher temperature than it would if admitted directly. (5) Provision for drawing off the foul air at the floor, as an alternative to ceiling outlets. With floor outlets, the air drawn off is colder than that drawn off at the ceiling, and hence the stable is not chilled so much. Ceiling outlets, however, encourage a more rapid ventilation, and it is therefore advisable to provide both,—by extending the foul air box to the floor, leaving the lower end open, and providing a flap in the box near the ceiling, to open or shut as is required.

The fourth problem in ventilation is to prevent dripping, or condensation of moisture in the stable. In an ill-ventilated stable, the moisture from the breath and from other sources often condenses on the cold ceiling or walls. In a well-ventilated stable, the moisture is carried off with the impure air before condensation can occur. There are two cases, however, in which ventilation is sometimes the cause of dripping. First, the moisture may condense on the pipes or boxes carrying the cold fresh air. This is more likely to occur if these pipes are at the ceiling of the stable, and especially if the cold air is admitted at the ceiling—the condensation occurring where the cold air comes in contact with the warm moist air at the ceiling. Secondly, dripping may occur from the outlet boxes, especially if these are long. The preventives of dripping are generally, a brisk movement of air, forcing the moist air out before condensation can occur; fresh air inlets at the floor; and outlet pipes as short and direct as possible.

PLANS OF VENTILATION IN DETAIL.

Following are various plans of ventilation that are actually in use in this country. There are advantages and disadvantages in all.

Some are comparatively cheap, some more costly. Some require more or less constant attention to prevent too great cooling; some are almost automatic. The distinctive features of each will be discussed in connection with the descriptions.

That most of the stables in this country stand in need of some form of ventilation more than is provided at present is evident from the

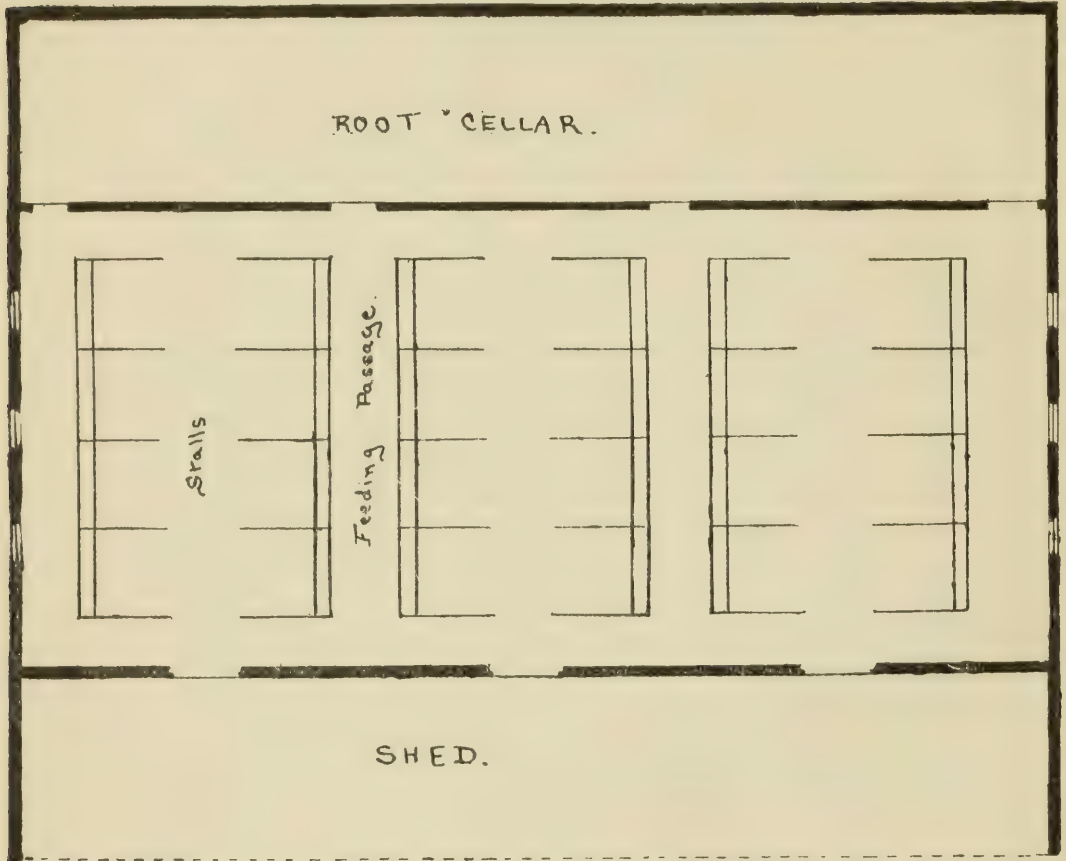


Fig. 2. Showing the great defect in many fine stables,—a limited amount of light and an equally limited amount of ventilation.

following instances, the first of which is furnished by a quotation from the "Nor' West Farmer" of April 20th, 1900: "I have built a stable with grout and roofed it with ship-lap. I find it too warm and close. My windows are made to open, but they let in so much cold air that the walls and roof are continually wet. I leave the feed shoot open to let out the warmth, but still the walls keep wet, and the drip from the roof falls on the stock. How can I best ventilate it so as to keep the wet off the walls?"

The second instance of an ill-ventilated stable is represented in Fig. 2, showing the plan of a stable. This building is known locally as the Model Barn, on account of its up-to-date arrangements and fixtures. From the illustration, it can be readily seen that in the construction of the building, two most important items were almost entirely ignored,—

light and fresh air. The stable, as the plan shows, is about 36 x 80, with a root cellar at one side along its whole length. Only the faintest of borrowed light and still less air can penetrate to the stable from this side. Along the other side is an open shed, with which the stable communicates by means of doors. When these doors are open, the stable gains a certain amount of borrowed light and air; when they are shut, the only media for conveying light and air are small fan-lights above the doors, covered of course with dirt and cobwebs, and apparently not intended to be opened. At each end of this long stable are three small windows, which struggle bravely to light the interior. How they succeed in the attempt in the gloomy days of midwinter may be conjectured, when it is stated that on a bright afternoon in May, the writer could not see to read or take measurements at the middle of the stable, and was compelled to move to the end near the windows in order to record observations. So much for light, and ventilation was no better. Not the smallest contrivance for taking away foul-air, moisture, and other harmful products so abundant in a crowded stable.

These instances illustrate the prevailing indifference to these matters that exists among builders. It is not a sufficient answer to say that the cattle in such a stable seem to get along well enough without fresh air and light, and that there is no need for going to trouble and expense to secure these conditions. It is true that impure air is very slow and insidious in its effects, and generally leaves no specific mark as a sign of its harmfulness. But it is none the less harmful to health and vitality.

DIMENSIONS OF PIPES, SHAFTS, ETC. It is very difficult to give any sort of rule that will suit even the majority of cases as regards the dimensions of ventilating arrangements. If we assume that an opening 6 inches in diameter will deliver, under ordinary pressure, enough air for one animal, then an inlet pipe 20 inches in diameter will furnish enough air for 12 animals. It would be proper to allow 25 to 30 square inches of inlet pipe for each animal. So that a box 3 feet wide and 1 foot deep, having, a cross-area of 432 square inches, would provide air for about 16 animals.

As to outlet pipes, the more of them the more perfect is the ventilation. Practically, however, it would scarcely ever be necessary to provide more than two or three of these outlets in the ceiling or at the floor. The total area of the foul-air shafts should be from one-fifth to one-tenth greater than the area of inlet pipes, since the warm air leaving the stable occupies greater space than the cool air entering. For instance if a box 3 ft. by 1 ft. is used to bring in the fresh air, then two ventilators 2 ft. by 10 in. would be sufficient to draw off the foul air. And it would be inadvisable to make the outlet much larger comparatively than this. When the ceiling ventilators are too large, there is often a down draft which interferes with the working of the system.

The first plan of ventilation to be described is that in use in the stable of Mr. W. D. Cargill, of Cargill, Ont. The description of the plan has been kindly furnished by the proprietor, and is here given: "Our barns all have a stone foundation 11 feet high, and around this, as close to the top as possible, we built in 5 or 6 inch tile about 6 feet apart, run-



Fig. 3. Ventilation of barn, by means of tile built in the wall.

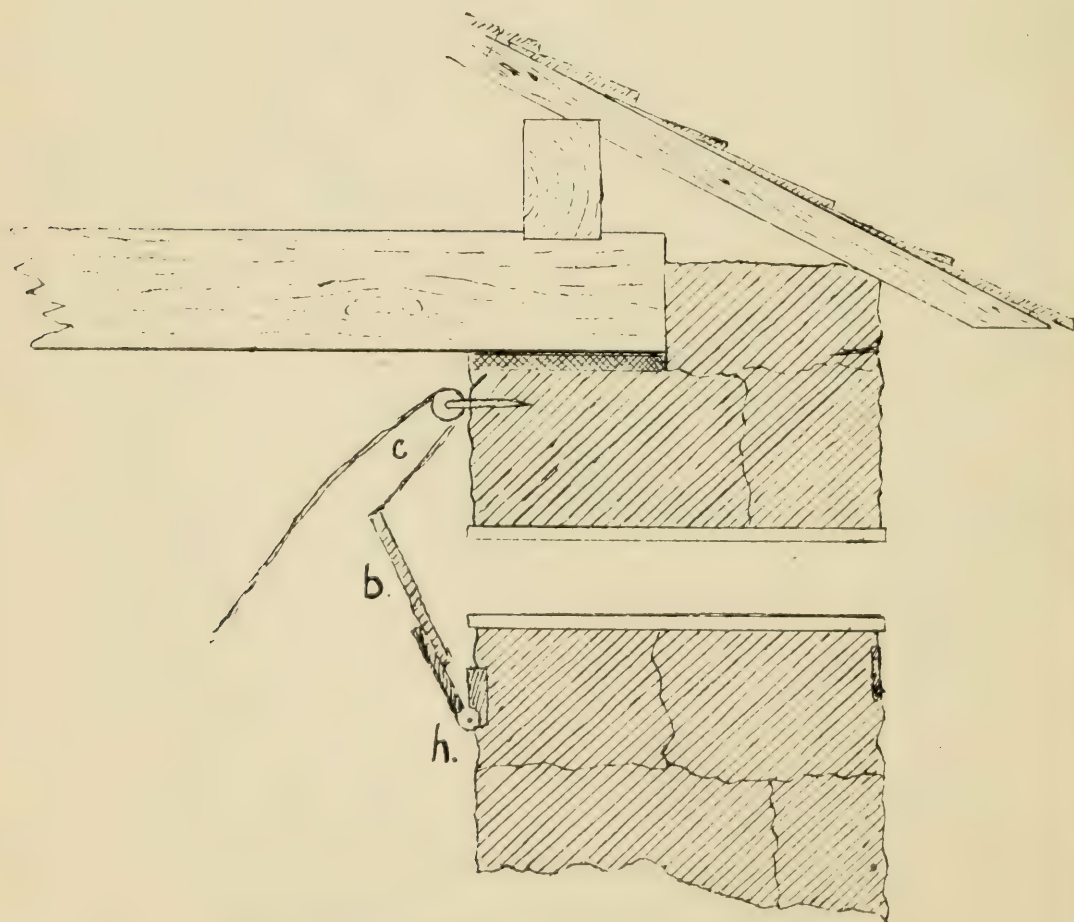


Fig. 4. System of ventilation by means of tile built in the wall.

ning through the wall. These are put in all around the building, and we find the plan gives all the ventilation necessary. If weather is extremely cold, some of the tile may be stopped up with a wisp of hay.

"We also have windows in foundation stand up as in a house, (most barns have them opposite) and top half of the window lowers if extra ventilation is required."

Fig. 3 is a horizontal section of the above plan of ventilation, showing a section through the wall at the level of the tiles. Attention is called to the statement of Mr. Cargill as to the occasional necessity of stopping up the tile with a wisp of hay. The writer suggests another plan for this, the same contrivance serving another useful purpose. Fig. 4 is a vertical section of the wall through one of the tile. The suggestion is that a 12 inch board, marked *b* in the plan, be hinged at *h*, and raised or lowered by a cord *c* passing over a pulley. By drawing the board close to the wall and holding with a hook or button, the pipes are practically closed. By tipping the board more or less on a slant, as in the figure, the incoming air is deflected upward and the danger of drafts may be avoided.

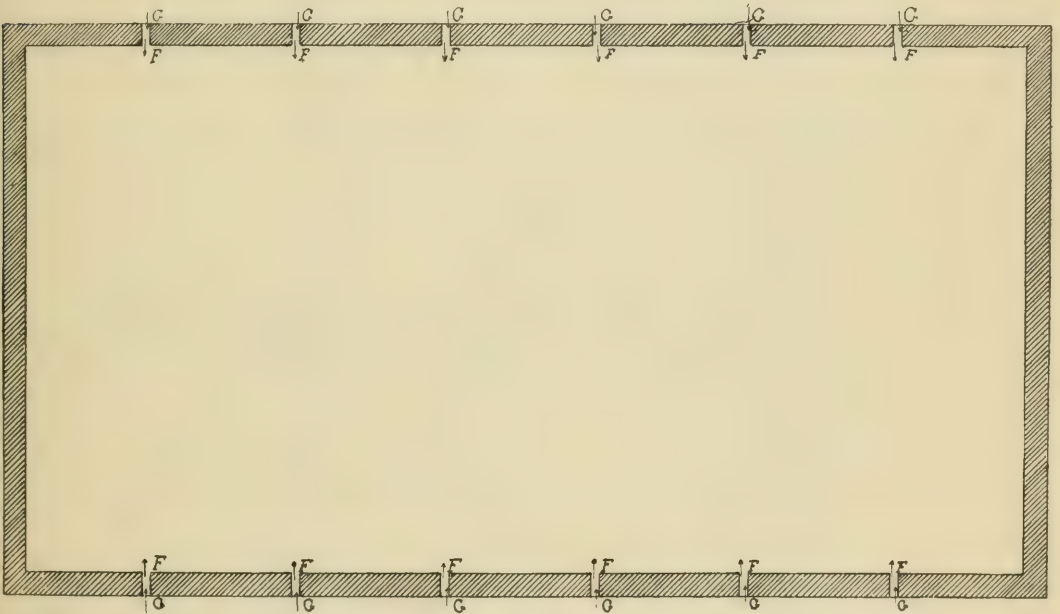


Fig. 5. Plan devised by Prof. King, of Wisconsin. Horizontal projection showing fresh air inlets.

Fig. 6 shows the system of ventilation originated by Prof. King for use in stables, and with his kind permission, the plan and his description of it, are inserted here.

A single ventilating flue D E rises above the roof of the main barn, and is divided below the roof into two arms A B D, one at each side, which terminate near the level of the floor at A. These openings are provided with ordinary registers, with valves to be opened and closed when desired. Two other ventilators, one at each side, are placed at B, to be used when the stable is too warm, but are provided with valves to

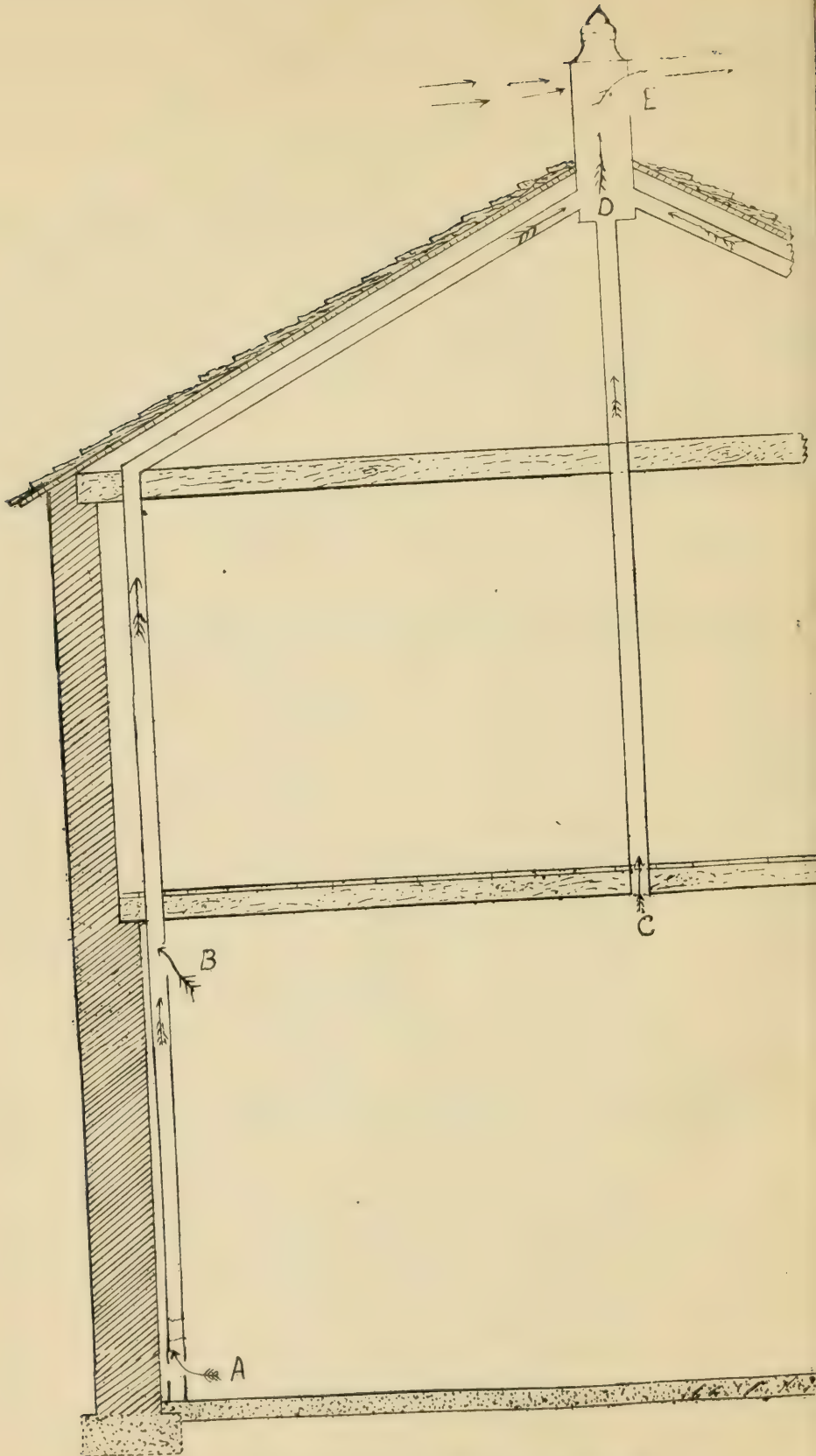


Fig. 6. Showing Prof. King's system of outlets.

be closed at other times. C is a direct 12 inch ventilator leading into the main shaft, and opening from the ceiling, so as to admit a current of warm air at all times to the main shaft to help force the draft. This ventilating shaft is made of galvanized iron, the upper portion being 3 feet in diameter. The air enters the stables at various points as shown in the plans 5 and 7 at F G.

Next is, represented in Fig. 8, the plan of ventilation in use at the stables of Dr J. G. Rutherford, Dominion Veterinarian, Portage la Prairie.

With his kind permission, the description given by himself in his paper on Stable Hygiene is subjoined :

"I got my first start from a very intelligent English farmer who was on a visit to this Province some eight or nine years ago. He recommended placing U pipes under the wall behind the horses, and drain tile through the wall over their heads, but was forced to admit on cross-examination that when the wind blew in through the latter his ventilation went on strike until the wind changed. I adopted the U pipe part of the plan, using, however, wooden boxes, but substituted for the drain tiles adjustable side louvres at the top of a large shaft running to the roof. These, however, were not a success, for the wind was sometimes in the opposite direction in the morning from that in which it had been at night, and on such occasions the stable smelt to heaven.

"I finally closed up the louvres altogether, putting in, instead, a galvanized iron pipe or chimney of considerable dimensions, furnished with an ordinary rain cap, and a large damper manipulated with cords from the stable floor. When the damper is open, the foul air, being warm, rapidly rises, passes out through the chimney and is steadily replaced by

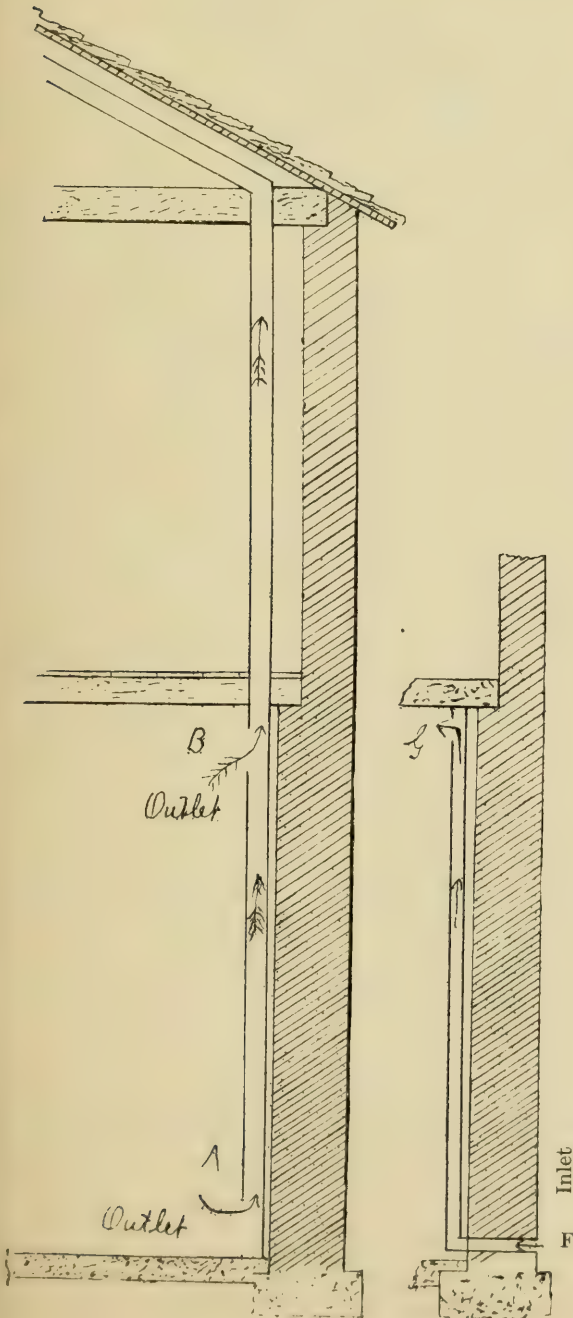


Fig. 7. King.

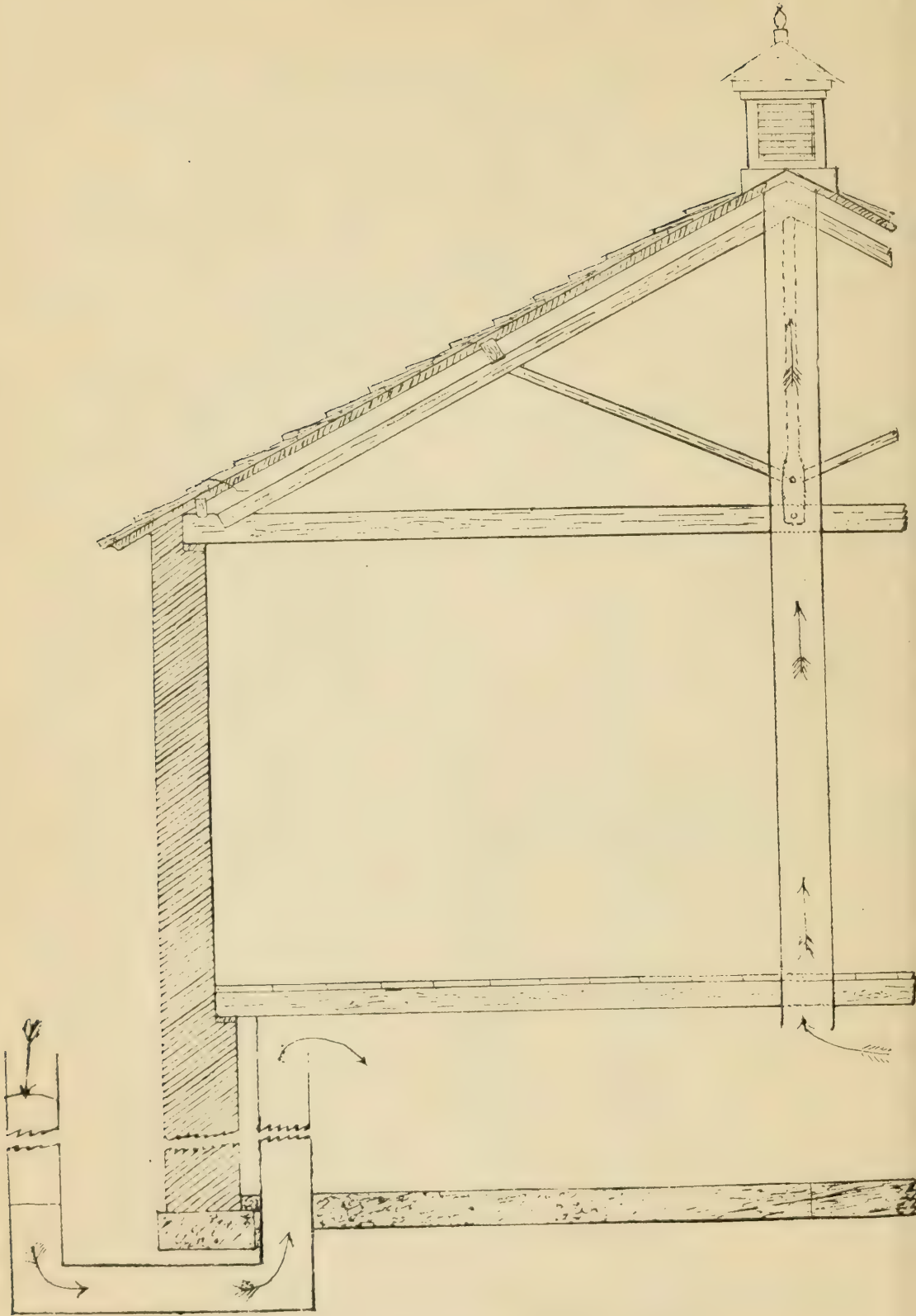


Fig. 8. Dr. Rutherford's plan of ventilation—U pipes.

fresh air sucked in through the U pipes or boxes. By closing the damper, the inrush of air through the lower pipes is at once checked, while a partial closure has a corresponding partial effect on the action of these inlets. In this way, the whole system is under easy control, and can be adjusted to suit the weather or the number of animals in the stable. . . . This plan has stood a fair trial, having been in operation for upwards of seven years. I may say that I would not exchange it for any system of winter ventilation I have ever seen. . . . By this plan a stable can be kept free from odors, and at a temperature during the coldest weather of from 35 to 40 degrees Fahrenheit, which is quite warm enough for healthy animals of any kind."

By way of further note on this plan of ventilation, it may be added that the outer arm of the U pipe may be of any length that seems advisable, while the inner arm should terminate near the ceiling, or may rise to the ceiling and extend horizontally for some length. Of course, it is understood that this system is not confined to one inlet pipe. The number of U pipes put in will depend upon the number of animals in the stable.

Figure 9 represents an inexpensive system of ventilation that is in operation at Dentonia Park Farm, of the late Mr. W. E. Massey, of East Toronto. The cowl, which revolves so as always to face the wind, is made of galvanized iron, and stands immediately above the peak of the barn, so as to catch the full force of the wind. The wooden box (or iron-pipe, as in the figure), which is the continuation of the cowl inlet, extends down through the floor of the barn to the stable beneath. The joints of the box or pipe should be practically air-tight. At the floor, the inlet shaft may be of wood, but land tile cemented at the joints will make a better and more lasting job. The outlet shafts, of which there should be two at least, in opposite parts of the stable, should extend up into the barn well above the hay and straw, if not quite through the roof. An excellent plan for the outer terminal of the outlet shaft is to provide a cowl that points away from the wind, thus increasing the driving power of the wind by giving it an aspirating effect at the mouth of the cowl. These outlet shafts might be used also as feed shafts for carrying hay or meal from the barn floor to the stable below.

By way of comment, there is given below a report of the working of the system, kindly furnished by Mr. J. B. Ketchen, superintendent of the Dentonia Park Farm. The report was written March 17th, 1900:—

TEMPERATURE. "I should think we had our supply shut off half a dozen times probably during the last winter. We rarely shut the outlet, and by careful watching the temperature can be regulated. In both the outlet and intake shafts there are revolving doors that can be shut by an attached string."

EFFICIENCY. "It is quite satisfactory. A horse stable is the most difficult part to ventilate properly, but in our stables I will guarantee that you could work all day, and your clothes would not have the smell of stables on them."

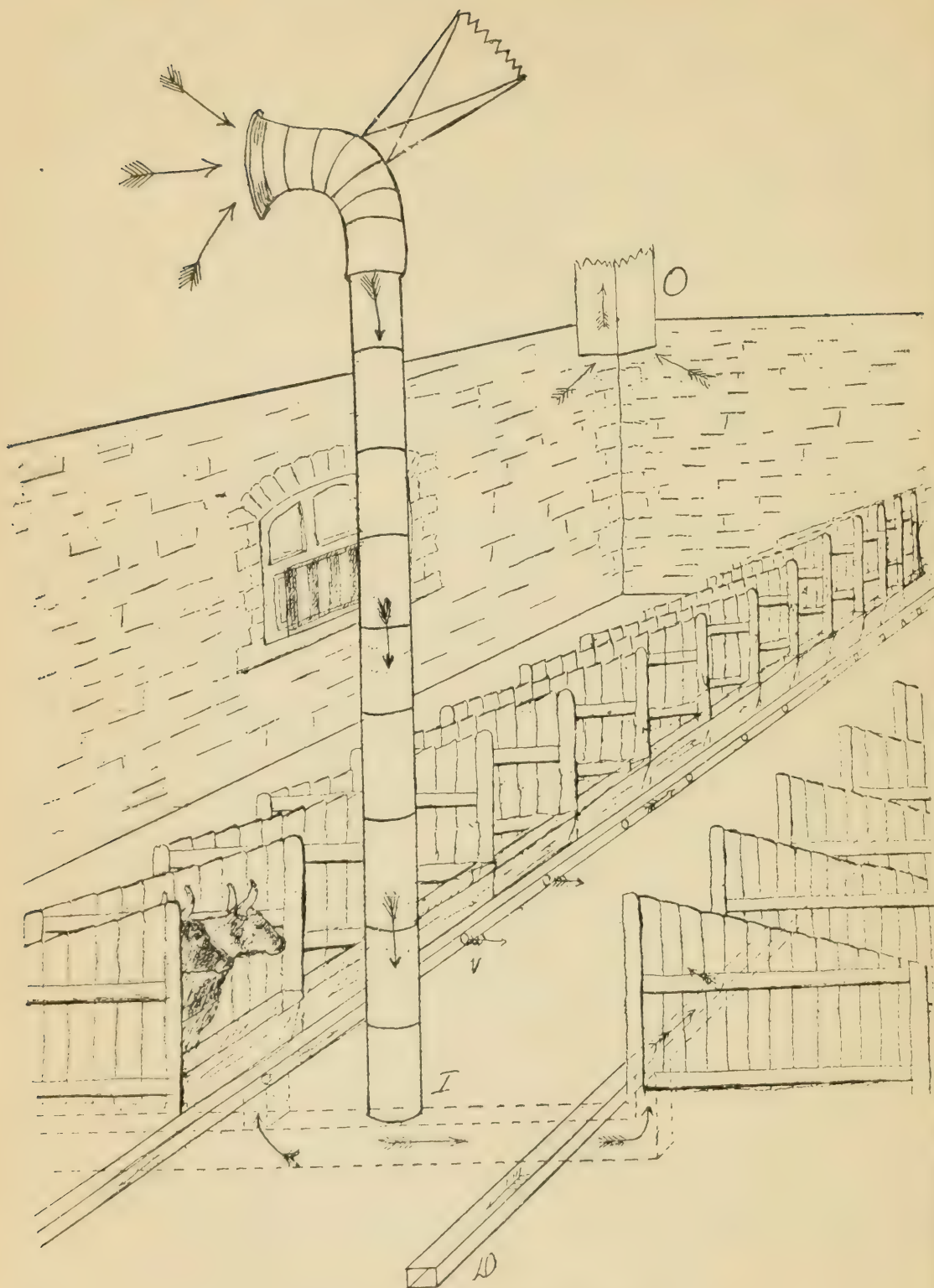


Fig. 9. Mr. Massey's plan of ventilation.

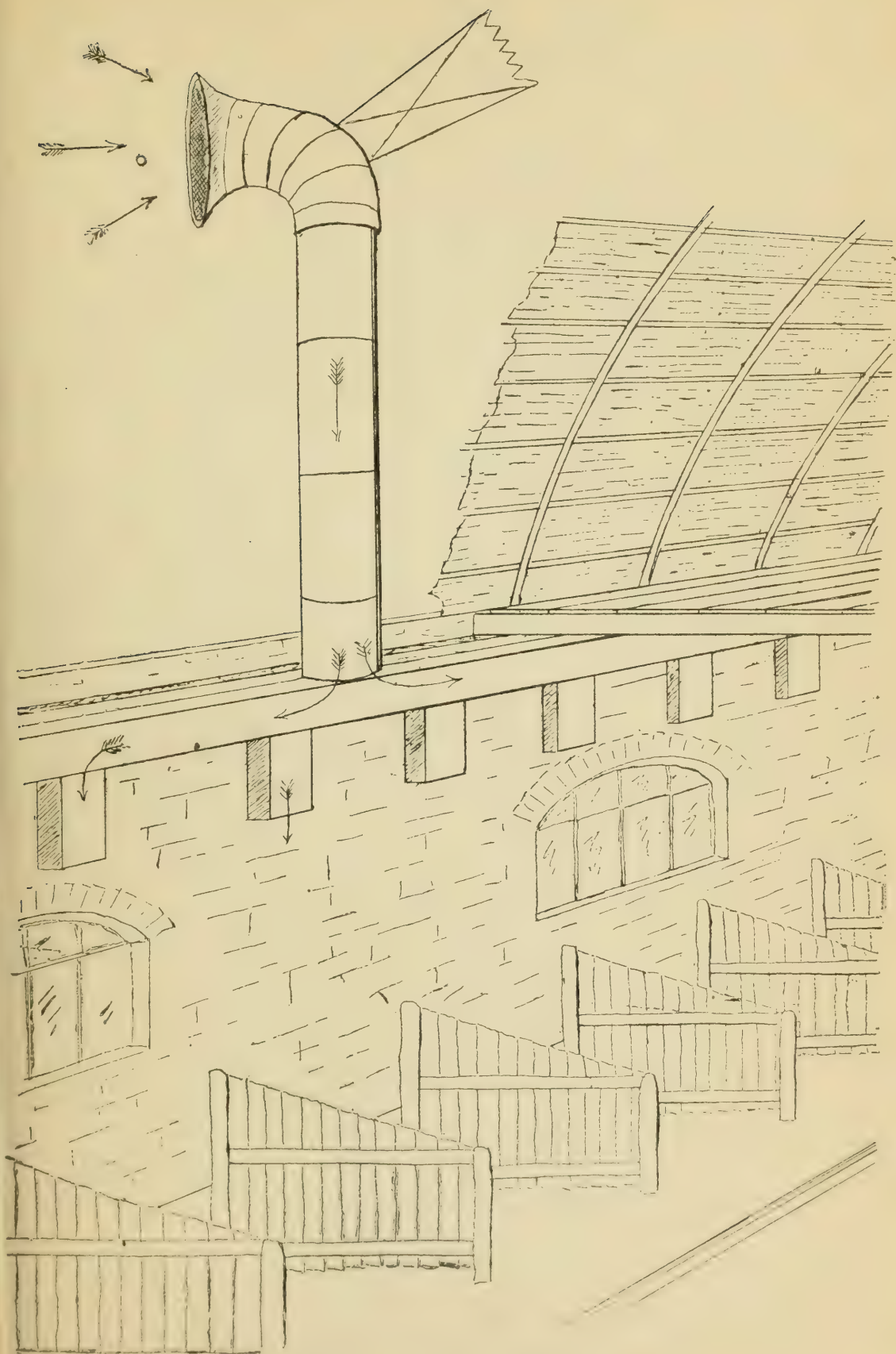


Fig. 10. Ventilation for stables already built.

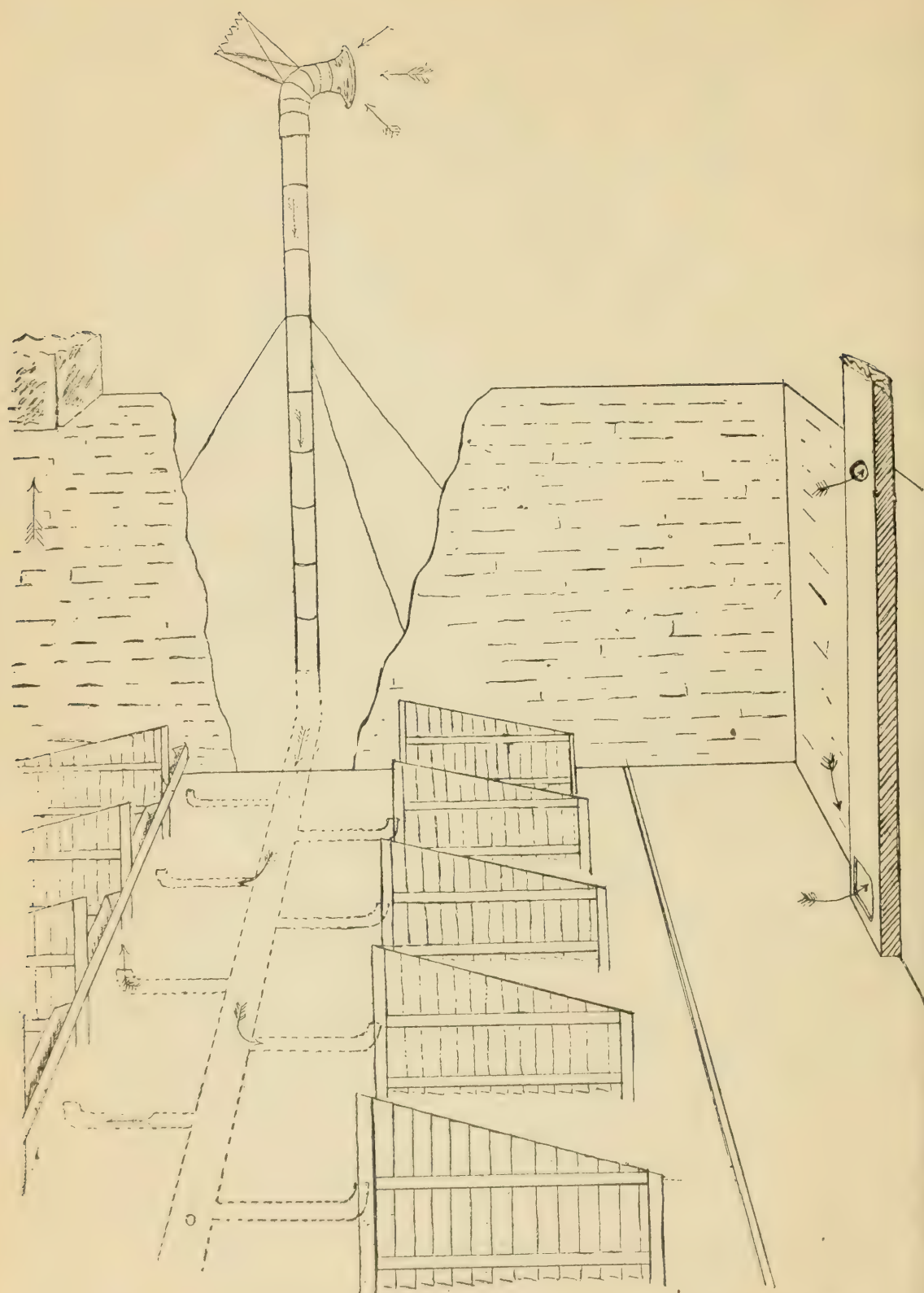


Fig. 11. System of ventilation using cowl, sub-earth duct, and flue in wall for foul air.

Fig. 10 shows a system on the same principle as that of Fig. 9, except that the air is distributed at the side-wall, instead of at the floor. This plan is suitable for old stables in which the pipes cannot be laid along or under the floor.

Fig. 11 shows the system of ventilation in Mr. Tillson's stables at Tillsonburg. It differs from that shown in Fig. 9 in the following particulars:

1. The inlet pipe, instead of being placed immediately above the roof, stands by itself at some distance from the barn, and the horizontal pipe lies eight (8) feet below the ground until it enters the stable, when it passes just below the floor of the passage. In this way, the air before entering the stable is warmed in winter and cooled in summer. At 8 feet below the ground, the earth temperature varies but slightly through the year, and the sub-earth duct brings the air nearly to a constant temperature.

2. The air is distributed by lateral pipes 9 inches in diameter and 8 feet apart, alternately on opposite sides of the main, and opening out at the floor level just in front of the mangers.

3. The foul-air shafts at the ceiling are supplemented by flues built into the wall about 20 feet apart. Each flue has a square or oblong opening near the floor, and a similar opening near the ceiling. This addition, while it increases the cost, increases the efficiency of the ventilation.

SIZE OF PIPES, SHAFTS, ETC. The inlet pipe is 24 inches in diameter, and is made to do duty for 40 cattle—an area of 11 square inches for each animal. This is less than half the area that has been mentioned as desirable. In this particular case, the amount of air might be doubled with but slight additional expense, by erecting a cowl at each end of the horizontal pipe, and sealing the latter at the middle, so as to virtually make two inlet pipes.

The *laterals* are 9 inches in diameter, and supply air to four animals, which is equivalent to a 4½ inch pipe for each. Such a provision is ample on a cold day, but not so on a calm mild day. It is best to supply sufficient space for the lowest rate of supply, since on a windy day, when the rate of supply is greater, the air can be diminished by shut-offs.

The *ceiling outlets* represented in Fig. 11 are in the original 4 feet square,—much larger than is necessary for ventilation, but convenient for the secondary use to which they are put, namely, to serve for feed-chutes. Mr. Tillson informed us that on account of the large size of these ventilators, a down draft was sometimes felt coming from them. In order to prevent this, and at the same time to allow of their use as feed-chutes, it would be a good plan to build them the size required for the second purpose, to a sufficient height, and then reduce them to about 18 inches or 2 feet square.

The *flues* are built in the wall and extend like chimneys well above the eaves. They are not essential to stable ventilation, but undoubtedly improve it, especially in large crowded stables. The openings near the floor provide a way of escape for disagreeable odors from the gutters, at

points remote from ceiling shafts. Also any heavy gases that have settled to the floor are best got rid of by this means.

The *sub-earth duct* is to be recommended for winter stabling, but is less desirable in summer. In summer the outside air after passing through the underground duct rises in relative humidity, and becomes somewhat damp. Where summer stabling is practised, the sub-earth duct may be an undesirable feature.

IMPROVED VENTILATION OF FARM STABLES AT THE COLLEGE.

When the present barn and stables at the College were built, a system of ventilation was devised and put into operation. The plan included three large louvred ventilators on the roof, connected with 10 boxes 2 ft. by 1 ft. passing down through the barn to the ceiling of the stable below. These ten boxes, 20 square feet of space in all, were intended as outlets, no inlets for fresh air being provided. It was found, especially in the winter, as a consequence of lack of inlets, that the outlet pipes were frequently converted into inlets, and cold, disagreeable down drafts were felt coming from the ceiling openings. Also, when the pipes consented to act as outlets, they returned part of their cargo in the form of condensed moisture, and there was a constant dripping. The result was, the outlets were kept stuffed with straw in the winter, and there was no ventilation.

The improved plan was built in the summer of 1901, and combined the two schemes represented in Figs. 9 and 10 above. Where possible, the air was carried to the floor of the stable, and distributed as in Fig. 9. In certain parts of the stable, however, it was impracticable to lay boxes along the floor; in such cases the air was distributed as in Fig. 10.

Prof. Day's report on the working of the scheme is appended. The report was written on Feb. 14th, 1902:—"The system of ventilation put in last autumn has been in operation about three and one-half months, so that we are in a position to judge of its efficiency. Unfortunately, our carpenter had not time to finish the work, and there are several important details yet to attend to. Chief among these are the outlets for foul air, which we purpose locating at intervals along the walls of the stable. They were to consist of shafts running from near the floor of the stable to the ceiling, and out through the side of the barn just above the stone wall of the basement. Each shaft was to have an opening at the floor and also one at the ceiling, the one at the ceiling having a trap door so that it could be opened and closed at will. In mild weather the upper outlets would be opened, but in very cold weather these would be closed, and only the colder air from the floor would be removed. In this way the temperature of the stable would be well under control. At present we have simply the original straight ventilating shafts running from the ceiling up through the centre of the barn to the roof. In very cold weather these shafts carry off the warm air too rapidly and we are forced to almost close the inlets to prevent freezing.

"In spite of the disadvantages mentioned above, there is a wonderful improvement in the air of the stable compared with previous conditions. Before we put in our present system, the air was close, clammy, and foul smelling. Now, it feels dry and healthful, though on the cool side. A somewhat cold, dry air, however, is much preferable to the damp, stifling warm air encountered in so many stables. Our cattle, including small calves, appear to suffer no inconvenience from a temperature of 40° because the air is dry. The same animals in a temperature of 55° to 60° , where the air is damp and foul, would suffer much more discomfort, to say nothing of the danger to health.

"There is no doubt that the system of ventilation is a success, even in its incomplete form and when the outlets are properly arranged the results will be eminently satisfactory."

VENTILATION OF HOUSES.

For the same cubic space, the number of occupants is usually much less in a house than in a stable. Nor does the contamination of the air in houses, for reasons not necessary to mention, proceed so rapidly as in stables. In addition, doors and windows are usually more plentiful, and chimneys, stoves, furnaces, and fire places aid materially in keeping up a ventilation without effort or extra cost to the occupants. To keep houses tolerably well ventilated should therefore be comparatively easy. And yet most houses are badly ventilated even in summer, and still worse in winter. The reasons for this state of things are manifold: First, many people have a horror of fresh air in the house, it being often associated in the mind with dampness and drafts; secondly, open windows and doors provide a way in for flies, and when it comes to a choice between two evils, the immaculate house-keeper prefers to keep her house closed up tight rather than admit flies; thirdly, in winter, changing the air of a room frequently means more fuel, since the incoming air has to be warmed. In spite, however, of this combination of circumstances and prejudices operating against a thorough and perfect ventilation, a partial and irregular ventilation is in operation in

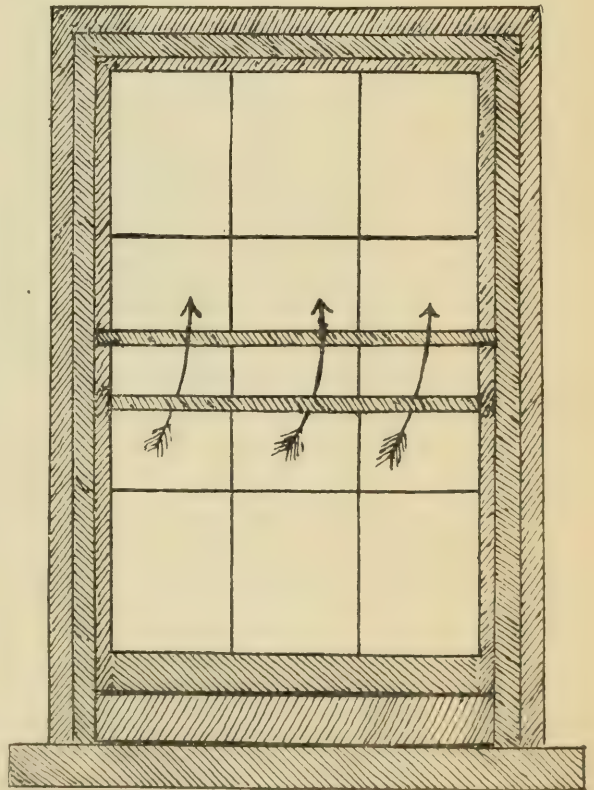


Fig. 12. House ventilation, showing lower sash raised and a board under.

all dwellings. The plans and suggestions given below, will, it is believed, aid in giving a more regular ventilation, in some cases to single rooms that are most constantly occupied, in some cases to the whole house.

VENTILATION OF SLEEPING ROOMS. It is undoubtedly a safe principle to lay down, that for persons in health, at least, it is more wholesome to have the air of the sleeping room pure, even if it is chilly, than impure, fetid and warm. Of course, many persons who have been accustomed to

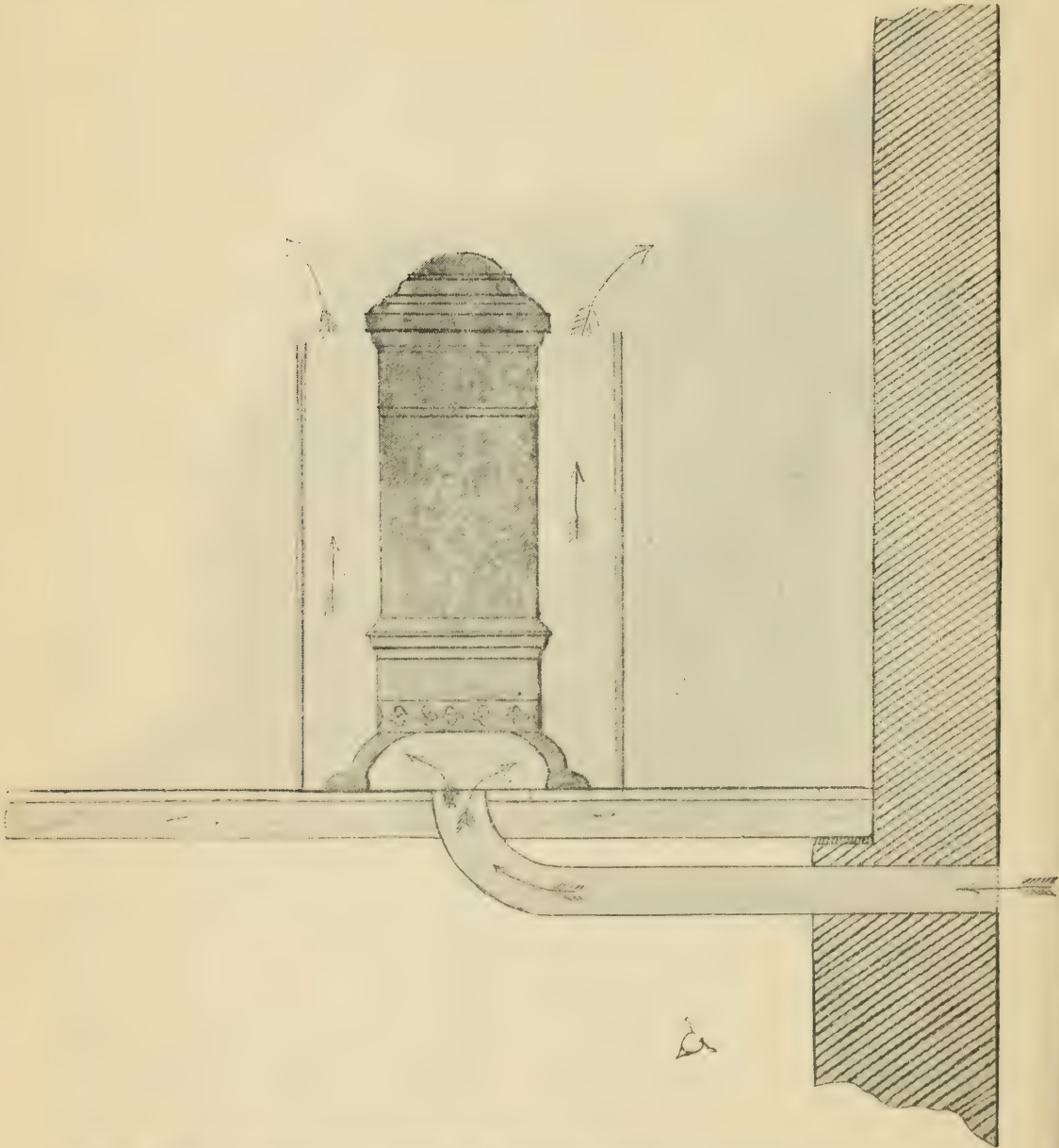


Fig. 13. Fresh air brought into a room, and warmed by passing up between the stove and a metal screen or jacket surrounding the stove.

warm tight rooms will shiver at such a cool suggestion. But that is because they have taught themselves or have been taught to sacrifice everything to warmth. With plenty of covering, one can sleep and sleep

better in a fresh cool atmosphere than in an atmosphere that is hot and stagnant. And there is no comparison between the healthfulness of the two conditions. With a window and a door in a room pretty good ventilation can be secured at almost any time. Even a draft is not objectionable if one does not lie directly in the draft. But drafts can be avoided by opening the lower sash and placing under it a board of the same width as the sash, as in Fig. 12. The air will find its way in between the sashes, and will stream upwards and spread without creating a draft. The impure air will find its way out of the doorway, the fanlight, or even under the closed door, if a small space is left below the door. Two windows in the room, raised as in Fig. 12, will give very good ventilation.

VENTILATION OF LIVING ROOMS. Any room that is occupied by the family during the day may be ventilated in winter with the aid of the stove or stove pipe. A valuable adjunct to all stoves used principally for heating is a *metal screen* or *jacket*, fastened to the floor and surrounding, or almost surrounding, the stove. This screen serves as a protection from the intense heat of the metal, and at the same time presents a larger radiating surface than the stove itself would do. But it is chiefly as an aid to ventilation that the metal screen is introduced here.

Fig. 13 illustrates a simple and efficient means of ventilation by use of the screen. The fresh air is brought in from the outside by a pipe under the floor, and passes into the room under the stove, and within the jacket space. The heat of the stove warms the air, and causes it to ascend, until finally it emerges from the jacket and spreads over the room. By such a device a circulation of the air is kept up, and a more uniform and comfortable temperature maintained throughout the room. This plan is especially to be recommended for school-rooms heated by stoves.

Fig. 14 illustrates a method of making use of the heat from the stove-pipe to provide fresh warm air for an upper room, or, if desired, for the room in which the stove stands. The fresh air is introduced as in the preceding illustration, the pipe rising through the ground floor and up through the floor above, widening out just after it leaves the lower floor so as to contain the stove-pipe, and at the same time to carry the required volume of air. The heat from the stove-pipe warms the air, and thus causes a current to ascend continually. By this means a constant stream of fresh (warm) air is passing into the bedroom above.

REMOVING FOUL AIR. The foregoing suggestions on House Ventilation relate to fresh air and to methods of bringing it into rooms. But in order to be able to bring in fresh air, the air which is already in the room must be drawn off. To this end, in addition to the ordinary means that require no care or contriving, there are certain devices of a special nature, yet simple and inexpensive. The best contrivance for removing foul-air is the *chimney flue*. With two or more flues built in the same stack, one of which is used as a smoke flue, when the latter is in use the smoke ascending warms the adjacent flue. If between this flue and the room through which it passes, openings are made for air, the warming of the air in the flue will create a draft upward, the air will be drained out

of the rooms and up the chimney, and thus the latter will serve the purpose of a ventilator. For this purpose, and also for the purpose of insuring a good draft for stoves, *all chimneys should be built in the interior of the house* and not in the outside wall. For good draft, either for smoke or foul air, the chimney requires to be kept warm, and there is much less loss of heat from an inside chimney than from one built on the outside.

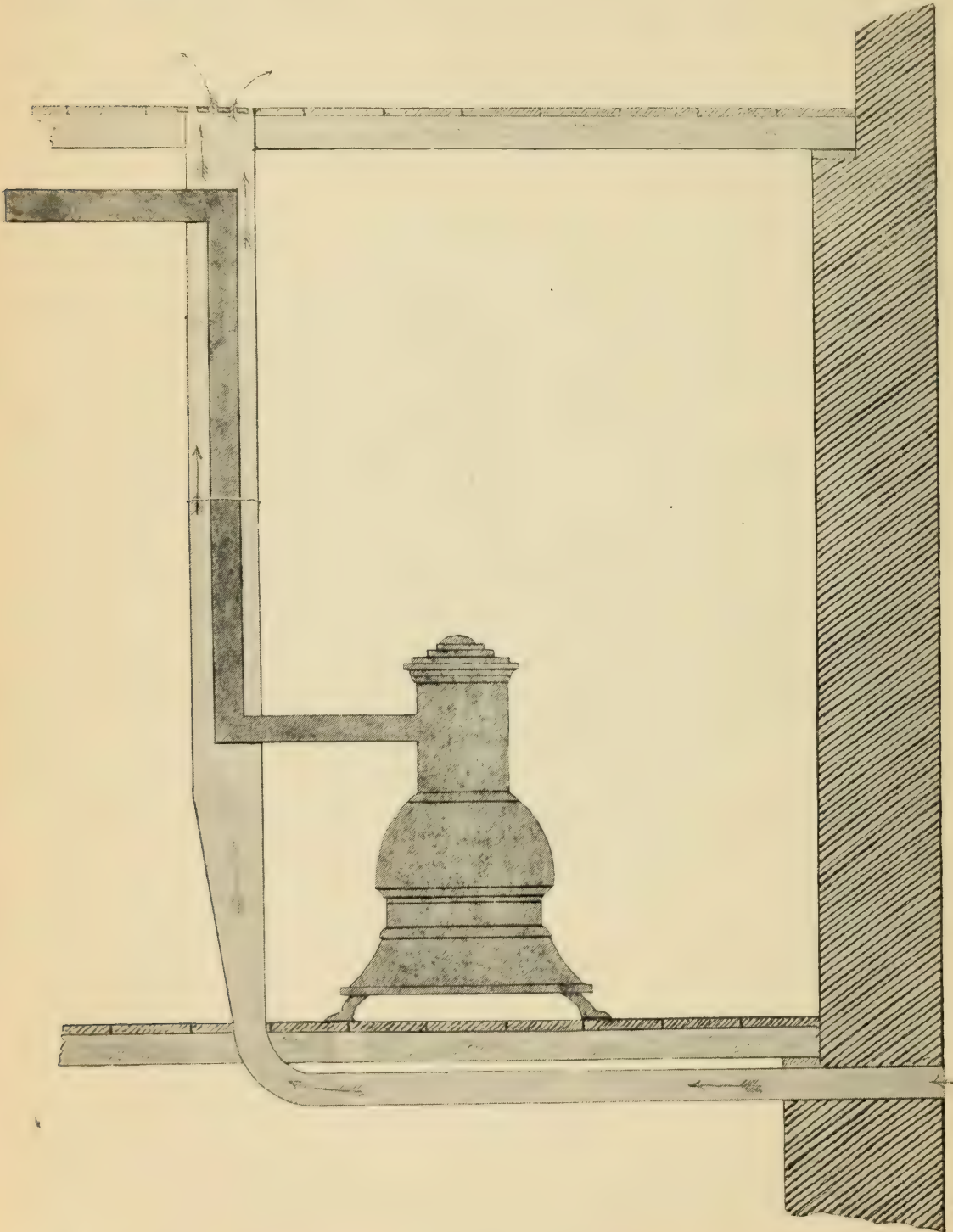


Fig. 14. Using heat from stove pipe to warm the air and to create a convection current. Furnishing warm fresh air for an upper room.

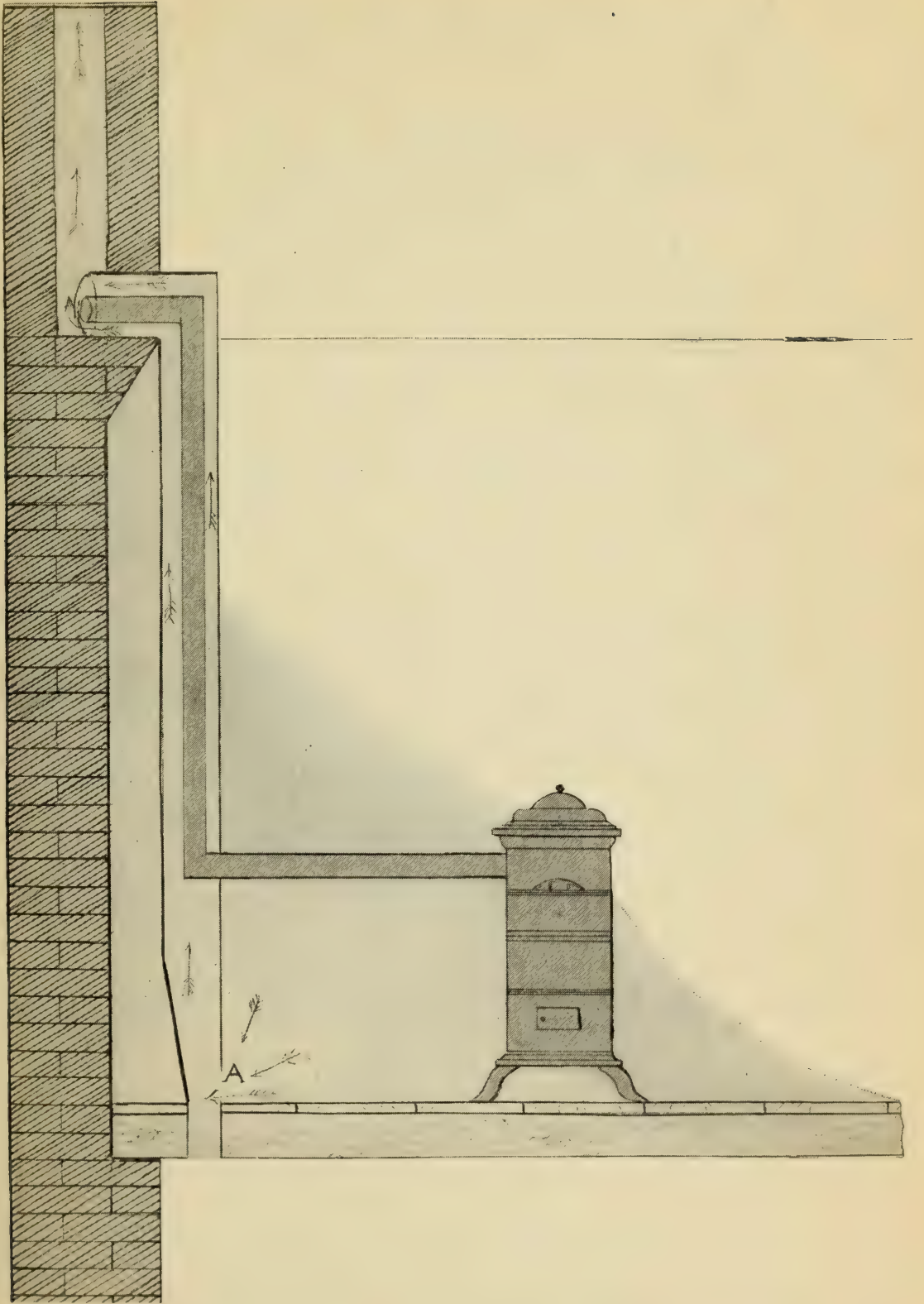


Fig. 15. Using heat of stovepipe to create a convection current for removing foul air.

All methods of removing foul air, though they may differ in detail, are identical in principle with the foregoing. In large city buildings and in schools of the more modern type, the flue is heated by means of a steam-pipe situated at its base, or, instead of the coil, a small coal-heater, called the auxiliary. The important thing to emphasize here is the *principle* by the operation of which a draft from a room is continually kept up. Knowing the principle, anyone interested can work out his own details; for each house, especially one that is already built, is a separate and distinct problem, the requirements of which could not be anticipated by even the fullest details.

One method whereby in the absence of the chimney flue, the latter may be successfully imitated, is given in the accompanying illustration, Fig. 15. In this case, it is supposed that the house is a two-story one, and that the chimney comes down only a short distance below the ceiling of the second story. The opening in the chimney is enlarged so as to admit a jacket for the stove pipe, much larger than the enclosed pipe. The jacket may be extended, as in the illustration, to the ceiling of the room below, and may thus be used to ventilate both rooms.

SUMMARY.

All plans of ventilation, to be effective and satisfactory, should possess in a greater or less degree, the following properties :

1. A motive force, by means of which the air is introduced and withdrawn.
2. A means of tempering the air before it enters the room.
3. A means of distributing the air uniformly over the space where it is required, and avoiding drafts and strong currents.
4. Sufficient provision for drawing off the foul air.
5. Automatic action.

The combination of all these properties, in the right degree, makes perfect ventilation, and no ventilation is perfect without this combination. Yet without all of these, very satisfactory ventilation may be had. If the external force is dispensed with, such a force as is represented in Figs. 9 and 11, there is still the heat from the bodies and the warm air from the lungs keeping up a constant upward motion of the air. If it is impossible to distribute the air as uniformly as seems desirable, then let the distribution be as good as possible, and it will be a long way ahead of no ventilation at all. If the plan cannot be made automatic, then it simply means more or less constant attention, and the time thus spent will be well spent.

With the preceding plans of ventilation, and the accompanying comments and instructions, the stockmen or householder may choose for himself, whether he wants the best and is prepared to pay for it, whether he will be satisfied with a fairly good system that yet has some disadvantage, or whether he will be content with an apology for ventilation, or with none at all.

Ontario Agricultural College and Experimental Farm.

BITTER MILK AND CHEESE.

BY F. C. HARRISON, PROFESSOR OF BACTERIOLOGY.

During the past summer one of the leading cheese factories of the Province was very much troubled with an affection known as *bitter milk*, which gave a very unpleasant flavor to the cheese. The trouble was not a new one at this factory. The year before last it caused some annoyance and loss, but not so much as last year; and even two years ago it was occasionally noticed; hence it would seem that the infection was increasing from year to year.

The patrons of the factory could not account for the trouble. They had been handling their milk the same way for years and had no trouble until a few years ago. Hence some were disposed to blame the maker. Others that had no silos blamed those who had, thinking that ensilage gave a bitter taste to the milk; and others again regarded Ragweed (*Artemisia ambrosifolia*) as the cause of the unpleasant flavor. None thought that the true cause might be a micro-organism,—because neither patrons nor makers have yet begun to realize the close relation of bacteria to dairying in all its branches.

This and similar troubles are constantly on the increase. J. W. Robertson (1), the Canadian Dairy Commissioner, states that during the first year that the creameries in the North-West Territories were operated there were no bad flavors; that, in fact, it was difficult to get proper souring; but now, not only does the ordinary souring progress in the usual manner, but also a number of bad and "off" flavors are met with. In Eastern Ontario, we have records of Rusty spot in cheese; and in New York, a number of troubles, such as Sweet Flavor in Cheddar cheese and Fishy flavor in milk.

Judging from the varied complaints and the increasing number of samples sent to the Bacteriological Laboratory for examination, it is evident that a serious condition of affairs exists, and that the methods of handling milk, as practised on the average farm, must be changed, if we are to improve or even maintain the reputation of our dairy products. Nor should the improvement be confined to the patron; for many factories also need improvement, the commonest defects, according to J. A. Ruddick of the Dominion Department of Dairying, being bad floors and drainage, cheap apparatus, and improperly constructed curing-rooms. These rooms become too warm in summer and give rise to the so-called "heated flavors." The chief defect from the maker's standpoint, according to the

same authority, is a weak, open body in the cheese, due to insufficient development of acidity during the process of manufacture.

I may also add that this lack of acidity not only causes open cheese, but sometimes gives rise to bad flavors as well, for the acid checks the development of many injurious bacteria that may be present in the cheese.

In August, 1901, we were asked by a large Western factory to conduct a series of tests in order to ascertain the cause of the bitterness in the milk. During that month the factory had bitter milk nearly every day, although it was very difficult to detect by smell at the time the milk was dumped into the weigh-can; but, in exceptional cases, the bitterness could be detected even then. The bitterness could be more easily smelt when the vat was warmed up for setting; and the odor increased as the curd was heated. When the curd was very bitter, the top of the whey foamed with small gas bubbles, especially when stirred.

The following notes on the making at the factory were supplied to me by Mr. Stratton, the College cheesemaker, who accompanied me on one of my visits:

CULTURE. About one-half of one per cent. culture was added to each vat at the time of commencing to fill with milk.

CONDITION OF MILK. Most of it seemed in fair condition, but on a few cans the so-called "bitter flavor" could be detected.

SETTING THE MILK AND HEATING THE CURD. The milk was ready to heat soon after heating up (average per cent. acid, per alkali test, .182). The agitators were set in motion soon after the cutting of the curd; then, after the temperature was raised to 98°, a hand rake was used. During the process of heating, the flavor became very pronounced on all the curds.

DIPPING. Most of the curds were dipped early. The whey was run off when the acid showed about $\frac{3}{8}$ in. on the hot iron (average per alkali test, .210). The stirring was continued from 15 to 20 times, according to the condition of the curd. The acid developed so fast on some curds that it would draw out about one inch. Before the stirring was completed, the curds showed also a correspondingly high acid per alkali test.

MILLING. The curds were ready to mill in a little over two hours from time of dipping (average alkali test, 1.152). After milling, they were washed with about eight pails of water at a temperature of 98°.

MATURING AND SALTING. When freshly milled, the flavor is strongest; but there seems to be a permanency about the bitter flavor; and there is little improvement while the curd is maturing. The mellowing down process is also very slow. Probably this is quite largely due to the excessive amount of stirring required to dry the curds at dipping time. In some vats the bitter flavor was more pronounced than in others, and was occasionally accompanied by an aromatic flavor, or fruity flavor, especially noticeable when one pulled up the cheese cloth to turn the curds at the end of the vat. The curds at salting time had a fine,

mellow, velvety feeling, although the change during the last hour and a half or two hours was slight. The curds showed a very high acid all through. Two curds, tested after milling and again just before salting, showed a gain of only .034 per cent. acid.

Samples of the bitter curd were brought to the laboratory, and among the micro-organisms separated was a yeast like species which produced a bitter taste in milk. Large numbers of other varieties of yeasts were present, some of which gave pleasant, ethereal odours when grown in beerwort.



FIG. 1.—Milk cans kept under trees. On the leaves of fruit and other trees many species of micro-organisms are found, and this illustrates how they get into the cans.

From the cultures obtained from the curd starters were made and added to the milk, and small experimental cheese were made therefrom. One of these cheese had a flavor which was very similar to, if not identical with, that of the cheese in the factory referred to, and, having thus succeeded in demonstrating that the bitterness could be produced at Guelph, and that it was due to a form of yeast, we decided to analyse bacteriologically samples of the mixed milk from every patron of the factory, to ascertain if the 'bitterness' came from the milk furnished by certain individuals, or if it was a general infection.

Samples of the milk of each person were taken in sterilized bottles as it was poured from his can into the weighing can. These were then packed in a box and sent to the laboratory. They arrived there in good condition. No bottles were broken and no corks were blown out. Cultures in beer-wort and beer-wort gelatine were made from each sample. The sample itself was placed in the incubator at 37.5° C. for 24 hours ;

and at the end of that time it was examined for gas, digestion of curd, and flavor. The wort cultures were also incubated at 37° C. for 48 hours, and then examined microscopically for the presence of yeasts. The wort gelatine plates were kept at 20° C., and, as the colonies developed, they were studied and, if necessary, isolated. In this way 99 samples of milk, from as many different patrons, were examined, and yeasts were found in 97, in many cases several species being present; but the predominant variety was the one giving rise to bitter milk, to which I have given the name of *Torula amara*, or the bitter *Torula*. *B. coli*, *B. lactis aerogenes*, *B. subtilis* were also present in the majority of samples; and the following species of bacteria and moulds were also quite common: *Oidium lactis*, *Penicillium glaucum*, *Proteus*, *Saccharomyces anomalus*, the pink *Torula*, and a number of species that were not determined, viz., yellow chromogenic forms, a red mould, a capsulated bacillus, various cocci, various yeasts, a slime producing bacillus, etc.,—a rich and diverse flora.

In fact, the bacterial flora was so rich that it was thought advisable to visit all the patrons, examine the conditons under which the milk was produced, and endeavor to locate the habitat of the bitter torula. The farms of some 82 patrons were visited. Samples of the foremilk (or first milk drawn from each teat) of a number of cows were taken; also of the can and pail washings; and, if the milking was done in the stable, a sterile Petri dish, the lower surface of which was smeared with sterilized gum tragacanth, was exposed for about a minute to the stable air, when the cover was replaced and the dish wrapped up in sterilized paper.

All these samples were then taken to the laboratory, where the examination was continued; but, before dealing with these results, we may say a word or two regarding the conditions among the patrons.

CONDITION OF COWS. The cows were in good condition and quite clean; there was scarcely a dirty quarter or udder to be seen. There is very little low-lying or marshy land in the neighborhood of the factory; and consequently, the cows are not soiled with dirt or stagnant water.

CONDITIONS OF STABLES. Speaking generally, we must say that the stables were badly lighted and poorly ventilated. The beam ceilings were usually very dusty, and generally festooned with cobwebs. The floors were fairly clean; but in some, the poultry had soiled the mangers, partitions, and racks to such an extent that a heavy, close smell was noticeable. Such stables gave a very large number of colon bacteria upon the plates exposed in the stable air. In other stables, swine were kept alongside the cows; and, in these cases, a very objectionable smell was present, very injurious to milk; and the bacterial content of the air was usually very large and very undesirable. It is also to be borne in mind that the air was quiet in the stables at the time of my visit. The cattle had been out some hours; and there was no disturbance of litter, etc., such as there would be when the animals were brought into the stable for milking.

A visitor to the factory was at once struck with the color of the cloths; and an examination showed that the color in the cloths was due to a chromogenic mould. This mould was very abundant in the stable air; in fact, we isolated it from 20 stables.

BARN-YARD. On several farms, the cows were milked in the yard, or in the adjacent lane. These yards were usually dry, but soiled with the droppings of cows, which constitute a source of infection, especially if wind is blowing. Milk drawn where these conditions were present contained very large numbers of the colon bacillus, and *B. lactis aerogenes*.

WHERE CANS ARE KEPT. The cans were kept in many different places, in or near the barn-yard, against an out building, under trees, on a milk-stand close to the road, or by the side of the house. In no case was there a properly constructed milk-shed, where the milk could be kept



FIG. 2.—On this side of the gate is the barnyard, in which the cows are milked. The can is shown on the right, in a position where the milk can be contaminated with undesirable bacteria from the yard.

and cooled. In several places where the cans were kept on a milk-stand beside the road, a good deal of road-dust was seen in them. Cans full of milk were often left in the barn-yard over night, in a favorable situation for the absorption of odors, as well as bacteria from dried particles of manure or dust which might be floating around (See figures 1, 2, and 3).

CONDITION OF CANS. The cans generally in use hold about 30 gallons. They have concave bottoms and one side seam, which is not always smoothly soldered. In some, however, the bottom is convex; and these latter are very much harder to clean, as the whey is left in a channel around the edge, and dirt there cannot be easily removed by the brush.

Very many milk pails are also very badly constructed with pressed instead of soldered seams and convex bottoms. The cans used by the patrons were usually in good condition as regards rust; but farmers purchasing cans should insist that the seam be soldered so that it presents a smooth surface that can be easily cleaned. In too many cases, the point of a knife can be inserted in the ill-fitting seam, and withdrawn covered with slime or dirt. It is impossible to clean a can thoroughly which has this grave defect.

METHODS OF CAN-WASHING. After the cans are emptied, they are usually scrubbed with warm water. Occasionally soda is used, and at some places, wood ashes, the latter being sometimes mixed with dirt or sand, which is apt to scratch the tin covering and permit the acid whey to act on the iron. After the rinsings are poured out, the can is scalded with hot water, poured from a large kettle around the inside of the can. The can is then rinsed with this water, which is left in the can until it is used, or the rinsing water is poured out. In some cases, *after the scalding*, the can is wiped with a rag.

The objection to the scalding in this manner is that the water is not hot enough. The usual practice is to take the kettleful of water from the house to the place where the cans are washed, and set it on the ground until the preliminary washing and scrubbing is finished. By this time, the water, instead of being at a temperature of 212° F., is about 190° F., and is still further cooled when poured down the sides of the cold can. The final wiping dry with a rag is a bad practice, as the cloth is sure to be contaminated with bacteria, which are thus rubbed over and deposited upon the scalded surface of the can. When the cans are finally scalded, they should be turned bottom up, tipped to one side (facing the sun), and left to dry in the air.

COOLING AND AERATION OF THE MILK. So far as I could ascertain, no form of cooler was in use among the patrons. The usual practice seemed to be "dipping," very often in an impure atmosphere, where bacterial infection was likely to occur. A few patrons used the "Kippen" aerator, but found it unsatisfactory in warm weather. Some kept the milk in pails immersed in a trough of water; but with no covering, except a wire screen to keep cats out. Even for large cans, this was the form of covering used; and the milk was thus left exposed to bacterial infection from the air.

Very few patrons know the difference between aeration and cooling, aeration meaning to them, in the majority of cases, cooling as well as exposure to air. Further, some cheesemakers in the past stated that cooling milk injured the cheese, or that it was impossible to make good cheese from cooled milk. This idea, promulgated before the use of acid cultures or starters, still lingers around many factories; and it is quite difficult to convince people that proper cooling is far more important than aeration. Aeration is certainly necessary when the milk is dirty or has absorbed

bad odors from being drawn in an impure atmosphere; but most of the better forms of coolers aerate as well as cool.

The situation among the patrons having been thus briefly and generally reviewed, a few words regarding the condition of the factory are necessary.

CONDITIONS AT THE FACTORY. The factory is well built, commodious, clean, and well managed. The floors are of wood in good condition, with cellar underneath with concrete floor, which is, however, somewhat broken. The drainage is fair. There is sufficient fall, and the overflow is carried away by a small creek. The water is of good quality, and cold even in summer.

The whey tanks are thoroughly washed out every week; but the drainage from them might be improved, as there is naturally some waste where the cans are filled by the milk drawers from the tanks, and this waste does not run away very readily.



FIG. 3.—Illustrating how cans are kept, the barnyard being on the left of the fence. This method is objectionable, because the cans are too close to the yard and are not protected from dust.

The windows and doors were unprotected by fly screens. Consequently flies were very numerous inside; and the infection from this source though not generally taken into account may be very serious. Some flies captured in the making-room were put into a test tube of sterilized water, shaken, and taken out again; and the water, on examination, showed that there were as many as 250,000 gas-producing bacteria per fly. Dozens of flies, at the time of my visit, were floating on the milk and whey; and they no doubt contributed a large number of undesirable bacteria to the milk. Fly screens on doors and windows would certainly help to keep out these pests.

The utensils were kept in good condition ; and also the vats ; but the curd sinks needed airing. It is true that they were well washed ; but they needed to be sweetened by being exposed to the air and sunlight ; and, as they are not used until about eleven o'clock in the day this could easily have been done.

The cheese cloths were of a peculiar red color, especially where they came in contact with the sink. The color was found to be due to a pigment secreted by a mould, which was quite common in the mixed milk, and which I subsequently found to be very common in dusty stables. The cloths were well cared for,—washed and boiled ; but the red color was not removed. They were in fact, dyed with permanent or fast color. Of course, in this case, the maker was not to blame ; but the patrons by cleaning and whitewashing their stables, could most probably have prevented the trouble.

CAUSES OF BITTER MILK.

Bitterness in milk is produced by several causes, which may thus be classified :

- I. Certain foods, such as, Ragweed, Lupines, etc.
- II. Advanced lactation, especially just before a cow becomes "dry".
- III. Disease of the udder. In Mastitis (or inflammation of the udder), the composition of the milk is considerably changed ; and a bitterness, or more commonly a salty taste, is produced. In most cases, this change is revealed by the appearance of the milk, which becomes a watery, serous-like fluid.

IV. The growth of micro-organisms in the milk.

In the first three, the bitterness may be noticed immediately after milking ; but if the bitterness is due to an organism, the bitter taste appears only after some time ; and it is with this cause that the present investigation deals.

Those not interested in the biology of the bitter organism will please turn to "Effects on Milk," page 14.

THE BIOLOGY OF THE BITTER ORGANISM.

As has already been stated, the organism producing the trouble was a *Torula*, which was found in nearly every sample of milk examined ; and in order definitely to characterise this organism, it will be necessary to give an account of its behaviour under different conditions of food, temperature, etc., information of importance to the bacteriologist, and thus necessarily technical, and of little interest to the maker.

HISTORICAL RESUMÉ. In 1860, Pasteur (2) whilst working on the theory of spontaneous generation, noticed that milk which had been boiled did not sour like other milk, but became bitter and contained butyric instead of lactic acid. Further, he noticed that the organisms obtained from the bitter milk were different from those he observed in

ordinary sour milk. They were motile, and were at first thought by Pasteur to be infusoria. By the use of a higher temperature he was able to destroy them; and then, step by step, he separated the lactic fermentation from the butyric.

Meissl (3) and Leow (4) somewhat later, noticed a bitterness the same as had been observed by Pasteur.

Duclaux (5) in his work on the ripening of Cantal cheese isolated a bacillus *Tyrothrix geniculatus*, which produced a bitter substance in the presence of oxygen. This organism was probably related to the hay bacillus.

Nägeli (6) in 1879 definitely stated that the bitterness was due to the action of micro-organisms which resisted the boiling temperature.

Liebscher (7) wrote on bitter milk in 1883, and noticed that after some days it putrified and that sulphuretted hydrogen was formed. He suggested the possibility that the change was due to bacteria, probably a form of *Proteus vulgaris*.

Hueppe (8), in his first paper published upon this subject, also definitely stated that the bitter taste of sterilized milk which had been standing some time, was not due to a change in function of the lactic acid bacteria, but that in such milk there were other bacteria which resisted the heat to which the milk was subjected and subsequently produced specific changes in the milk. He referred the bitter taste to *B. butyricus*. This germ, however, is not identical with other butyric acid bacteria found by Van Tieghem, Prasmowski, and others.

Loeffler (9) found in milk four bacteria (*B. Liodermis*, *B. Mesentericus vulgatus*, *B. lactic albus*, and *B. butyricus*) which gave to sterile milk a biting and slightly bitter taste. These germs produced peptone and butyric acid.

Kruegger (10) isolated from a sample of bitter milk a species of bacillus very similar to, if not identical with, *Proteus vulgaris*. This germ produced butyric acid, as well as the well known putrefactive fermentation. He deemed the trouble due in some instances to micro-organisms, probably *Proteus*, but gave no account of sterilized milk being made bitter by the growth of this germ in it.

Wiegmann (11) found a bacillus in sweet milk which, when grown in sterilized milk, gave a very strong bitter taste in 24 hours. This organism, even after one month's growth in milk, did not curdle or digest the casein. In old milk cultures, the bitter taste changed to a salty bitter one. Wiegmann questioned the conclusion that butyric acid produced a bitter taste, as this acid has of itself no bitter taste. His bacillus produced no butyric acid, and he thought that the bitterness was due to the decomposition of the albuminoids of the milk.

From a sample of bitter cream, Conn (12) isolated a micrococcus which gave an extremely bitter taste when grown in sterilized milk. This organism curdled milk with a slight acid reaction and subsequently the curd was somewhat dissolved, and the liquid formed was slimy.

When grown in bouillon, the odor, taste, and sliminess resembled that of the bitter milk. The presence of butyric acid was determined in the culture, and butter made from the bitter milk was rancid,—after two days it was “strongly rancid, and the taste strong and burning”

This case of Conn’s is noteworthy as being the first example of bitter milk naturally experienced. Previous cases were usually associated with imperfect sterilization of milk, due to the growth of spore-forming organisms.

Wiegmann’s germ does not seem to have been of economic importance, as it was isolated from sweet milk, and Kruegger cannot be said to have substantiated his statements by direct infection and subsequent production of bitterness by means of his *Proteus vulgaris* species.

Hueppe (13) in his second paper referred the bitter taste to *Mesentericus vulgaris*, as well as to *B. butyricus*. He expressed the opinion that bitterness was due to the production of peptones, and in support of his opinion, cited the fact that all the bacteria found in bitter milk belonged to the class of peptonizing organisms (those that liquefied gelatine); but he did not deny that there were bacteria which were capable of producing bitter substances of a special nature. We must also remember that there are very many bacteria which liquefy gelatine, but do not produce bitter milk, which latter is by no means a common occurrence.

Bleisch (14) isolated from milk imperfectly sterilized by the Neuhauß-Groniwald-Oehlmann’s method a bacillus which produced bitter milk. Peptone was produced. This germ formed spores which resisted a temperature of 100° C. (steam heat) for six hours. It was probably allied to the *B. butyricus* of Hueppe.

De Freudenreich (15) isolated from a bitter cheese a coccus, *M. casei amari*, which produced a bitter taste in both milk and cheese. It produced acid and liquefied gelatine, a rather remarkable combination. Cheese made from milk containing a culture of this organism was bitter. It produced peptone (0.8%); but the bitterness was not entirely due to peptone, as de Freudenreich succeeded in separating bitter substances which did not belong to the peptones.

The same worker also isolated from cream another species, *B. liquefaciens lactis amari*; and fresh cheese inoculated with this germ had a disagreeable, bitter odor. The germ probably belonged to the putrefying organisms.

O’Callaghan (16) found a yeast which gave a sharp, bitter taste to milk, forming alcohol. He stated that it would be injurious to butter-makers, and still more so to cheesemakers, although no experiments were made to support these statements. He named it *Saccharomyces lactis*, but did not describe it; and Beyerinck also gave this name to a yeast he found in Kephir.

INVESTIGATIONS AT GUELPH.

During the summers of 1899 and 1900, samples of bitter milk were

occasionally sent to our laboratory; but last summer the complaints became so frequent that we thought it advisable to make a thorough investigation of the trouble in connection with the factory above referred to.

TORULA AMARA

SOURCE AND HABITAT. A torula which gave a bitter taste when grown in sterilized milk was repeatedly isolated from hundreds of samples of cheese and milk, can-washings, whey, etc., which were analyzed.

The well-known fact that yeasts are constantly found on the surface of fruits and leaves—as, for example, *Saccharomyces Comesii*, found by Cavaia (17) on the pedicels of Millet; *Saccharomyces Ilicis*, discovered by Grönlund (18) on the fruit of *Ilex aquifolium*; and a yeast present on the fruit of the Mahwa (*Bassia latifolia*), a Sapotaceous tree from the flowers of which a strong alcoholic drink is made—led me to examine the trees and fruit near where the milk cans were kept; and from the leaves of certain species of maple, I isolated a torula identical with the species so frequently found in the milk and can-washings. This torula I have named *Torula amara*.



FIG. 4.—Camera lucida drawing of the Bitter Torula (*Torula Amara*), Leitz oc. 4; obj 1-12. Wort culture, 4 days at 37° C.

FORM AND SIZE. Grown in beer-wort (11.2 Ball) in Boettcher's moist chamber, the cells are generally oval in shape, and of varying size. Some are as long as 10 μ , but the average lies between 7.5 and 9.0 μ . After some days' growth, the cells become filled with large vacuoles, and the cell wall somewhat loses its sharp outline. Buds are usually formed at the smaller end of the cell. In milk (24 hrs. at 37° C.) the cells are usually oval, but round and egg-shaped ones occur. The cells occur singly, in short chains of three or four, or in small clumps (See figure 4).

On beer-wort agar at 37° C., the cells are somewhat larger, more irregular in shape, and contain numerous small oil drops.

SPORE FORMATION. No spores are formed. Spore blocks made from young, vigorous cultures, kept at 20°, 25, and 37° C. for 7 days, and observed at short intervals, contained no spores. Cultures in wort, peptone whey, and yeast water never produced spores at the temperatures given above, even when all conditions prescribed by Hansen were present.

There has not been any formation of spores in old cultures, some of which have been under observation for four months. Thus the organism is not a true *Saccharomycete*, but a *torula*.

WORT (11.2 BALL.) In two days, at 25° C., there is an abundant growth; the liquid is slightly turbid, but there is no pellicle or film. On shaking, numerous small bubbles form a deep layer of foam on the surface. In four days the liquid is clear and bright; no pellicle ever forms; about 2 per cent of alcohol appears. In cultures kept in small Erlenmeyer flasks at 37° C., a "yeast ring" forms; but, at room temperature, no ring develops, even after two months' growth.

The reaction of the wort, after fermentation ceases, and the carbonic acid gas which is driven off, is very slightly acid. In whey containing 1 per cent. peptone and .25 per cent Nährstoff Heyden, the growth is very similar to that in wort. There is an active fermentation and the reaction of the medium afterwards is slightly acid. In whey which has been boiled or filtered, 3 per cent alcohol forms in 8 days at 37° C., and no trace of sugar is found. In yeast water, there is a heavy deposit; the body of the liquid is clear and bright, and no film is formed.

WORT GELATINE. In two days, at 20°, pin point colonies, about 0.5 m. m. in diameter, are visible, the surface ones being slightly convex. Under the microscope (2-3 obj.), the colonies are dark with entire edges. In four days, they are round, greyish white, shiny, and from convex to capitate. They are not at all characteristic.

BEEF PEPTONE GELATINE. Colonies in this medium are somewhat smaller, but resemble those in wort gelatine. In four days, they are still similar to those described above, but under the microscope the edge of the colony is slightly rough.

WORT GELATINE STICH. In ten or twelve days, the line of puncture is beaded. The beads are distinct, and of considerable size; later (20 to 30 days), a dense, spiny growth radiates from the beads; but the projections are not sufficiently long or branched to justify the term arborescent. They may be called echinate. The surface growth spreads from 10 to 15 m.m., is umbonate, waxy, greyish white in color, but of a light brown shade towards the centre.

WORT GELATINE MASS CULTURE. These cultures were made by placing a drop of wort culture on the surface of the gelatine. The surface growth spreads over the entire surface in 30 days. The edges are thin and slightly rough. The centre is elevated, forming a plateau, which is

quite flat, or slightly depressed, and about 8 to 10 m.m. in diameter. The under surface of the growth is pulvinate and extends downward into the gelatine to a depth of 4 m.m. ; and very short, crowded, echinate projections demarcate the line of contact between the growth and the gelatine.

WORT AGAR SLOPE. Grows very quickly at 37° C., and in three days a slightly raised, spreading, greyish, white, moist, glistening growth is seen, which becomes more massive with age.

BEEF PEPTONE AGAR SLOPE. In eight days, at 25° C., there is a flat, somewhat glistening growth, iridescent like mother of pearl.

POTATO. On this medium there is a slightly raised growth in three days at 20° C., only distinguishable from the color of the potato by its dull appearance. In seven days there is no change. At 37° C., the growth is slightly yellower, otherwise similar to that at 25° C.

SACCHAROSE MEDIA. In Conn's medium, with the addition of 6 per cent. saccharose, a trace of gas forms after seven days' growth at 25° C. No film is formed, but there is a heavy deposit.

In yeast water, with the addition of six per cent saccharose, and under the same conditions, considerable gas is produced. There is no film, the body of the liquid in both cases being clear; but there is a heavy deposit. The sugar is inverted (Fehling's solution) In bouillon containing one per cent. peptone, 25 per cent. Nahrstoff Heyden, five per cent. salt, and 6 per cent. saccharose, gas is produced, and the growth resembles that in saccharose yeast-water.

DEXTROSE MEDIA. In Conn's medium, with six per cent. glucose, there is a slight trace of gas in seven days at 25°. There is no film, no turbidity, but a heavy deposit.

In yeast water, dextrose (six per cent.), the growth is similar to that Conn's medium, but there is more gas

In peptone-Heyden-saccharose (six per cent.) bouillon, some gas is produced, but otherwise the growth is the same as above.

LACTOSE MEDIA. In Conn's medium, with six per cent. lactose, there is considerable turbidity in both arms of the tube. There is no film, and 90 per cent. gas is formed.

In yeast-water lactose (six per cent.), the liquid is clear, there is no pellicle and 95 per cent. gas is formed.

In peptone-Heyden-lactose (six per cent.) bouillon, the growth is similar to that in yeast-water lactose, and 96 per cent. gas is produced.

MANNITE MEDIA. Conn's medium, with six per cent. mannite, is not fermented, and there is but slight growth.

In yeast-water mannite no gas is formed, but the growth is slightly heavier than in Conn's medium.

MALTOSE MEDIA. In peptone-Heyden-lactose (six per cent.) bouillon, a slight trace of gas is formed. There is no film, the liquid is clear, but there is a heavy deposit.

EFFECTS ON MILK.

MILK. In sterile milk the bitter taste can be detected after five or six hours growth at 37° C. In 14 hours the taste and smell are disagreeable and strong. The odor of cultures a few days old resembles plum kernels, and the taste is very unpleasant, bitter and astringent. In 10 days, at 37° C., the milk is slightly thickened, slightly acid, and the odour and taste are both pronounced. A slight, aromatic, ethereal smell may also be detected, but it is frequently masked by the bitter taste. There is much gas formed.

Culture gives the biuret action, indicating the presence of peptones. No butyric acid is present.

EFFECTS OF DRYING, ANTISEPTICS, ETC., ON *TORULA AMARA*.

THERMAL RELATIONS. The optimum for growth is about 37° C. (98.6° F.). Growth at 25° C. is abundant, and at 20° considerably slower. No growth occurs at 5° C. (41° F.), and none at 48° C. (118.4° F.).

The thermal death point was determined in triplicate, by Sternberg's method in whey bouillon :

Ten minutes at 56° C. : living.

Ten minutes at 60° C. : in two tubes, no growth ; in one, much growth.

Ten minutes at 62° C. : no growth, all dead.

A moment's exposure at boiling temperature (98.5° C. in Guelph) : growth.

Five seconds at boiling temperature : no growth.

Ten seconds at boiling temperature : no growth.

As this *Torula* was found in the can washings of nearly all the patrons, a practical test was made to see if the ordinary scalding with water at about 200° F. was sufficient to kill it. A 25-gallon, straight-sided can was thoroughly steamed, and then rinsed with a culture of the bitter torula. At the end of twelve hours the can was cleaned with warm water, and a kettleful of water at 200° F. poured down the inside and then well rinsed, and the water poured out. After this, the can was rinsed with sterile wort, which was then collected in a sterile bottle, and incubated. In 12 hours there was abundant development of the *Torula*. The amount of water used for scalding was 3 pints ; and the experiment was afterwards repeated using 12 pints, but with similar results, the *Torula* not being killed.

EFFECT OF DESICCATION. Cover glasses spread with a 24-hour-old culture were exposed in the open air to dry at a temperature which varied from -15° C. to 5° C. A cover glass was placed in whey bouillon at the end of every 24 hours. For the first 7 days, growth occurred in all the cultures ; but on the 8th and following days no growth occurred.

EFFECTS OF ANTISEPTICS. A 2 per cent. soda solution at 55° C.

(131° F.) failed to kill the *Torula* in 5 minutes, but in 10 minutes all the cultures were sterile. A 4 per cent. solution killed the *Torula* in 5 minutes.

ACTION OF ACIDS. The determination of the amount of acidity in the culture medium (yeast water) was made after sterilization.

(1) Tartaric acid (1.125 per cent.)—More growth occurs in cultures with this amount of acidity than in the control cultures.

(2) Tartaric acid (2.025 per cent.)—There is some growth, slightly less than that in the control tubes.

(3) Lactic Acid (1.2 per cent.)—More growth occurs in cultures with this amount of acidity than in the control tubes.

(4) Lactic acid (2.4 per cent.)—There is a flocculent deposit, and less growth than in the control tubes.

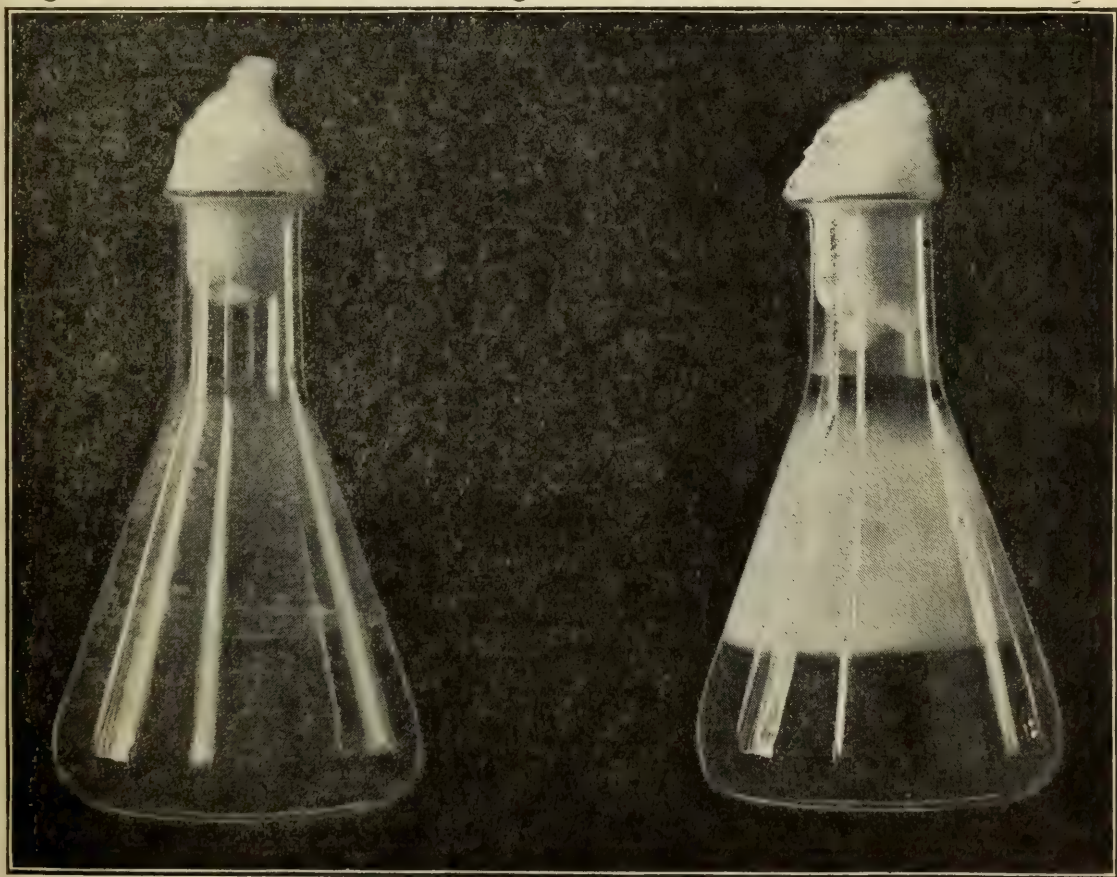


Fig. 5. The bitter *Torula* (*torula amara*) in whey—(a) before shaking; (b) after shaking. Note the large amount of gas (froth) in the latter.

EFFECTS OF ACID WHEY ON *TORULA AMARA*.

By the rapid development of acid in whey, cheesemakers are able to control many abnormal fermentations; and it is, therefore, of consider-

able importance to ascertain whether or not the bitter flavor may be controlled in this way. A number of experiments were made to determine the effect of acidity on the bitter *Torula*.

In the first series, acid whey, containing 1.08 per cent. lactic acid, was used, and the vigor of growth was determined by the amount of fermentation. In such a medium, 50 per cent. gas was formed. The control culture in ordinary whey gave 85 per cent. When neutral sterile whey was inoculated with the bitter *Torula* and *B. acidilactici* together, 70 per cent. gas was formed. Acid whey (1.08 per cent.) simultaneously inoculated with the *Torula* and the lactic acid bacillus gave 48 per cent. gas.

These results, taken alone, seem to indicate that a considerable amount of acidity somewhat prevents the activity of the *Torula*; but I subsequently repeated the above experiments, using the same *Torula*; and, after repeated transfers in whey, it gave a more vigorous fermentation than originally. With this culture in fermentation tubes containing whey peptone bouillon, kept at 37° C. for 48 hours, I obtained the following results:—

<i>Torula amara</i>	90	per cent. gas.
“ “	88	“ “
“ and lactic acid bacillus.....	90	“ “
“ “ “	76	“ “
“ “ “	87	“ “

Whey and skim-milk mixed:—

<i>Torula</i>	93	“ “
<i>Torula</i> and lactic acid bacillus	94	“ “

SKIM-MILK. In this case, the lactic acid bacillus coagulated the milk and formed a solid curd, which shrunk and adhered to the sides of the tubes; but the gas forced the whey into the open arms, leaving the following amounts of gas in the closed arm:

<i>Torula</i>	94	per cent.
<i>Torula</i> and lactic acid bacillus.....	92	“ “
“ “ “ “ “	89	“ “

These more extended experiments go to show that the development of acid does not hinder the growth of the *Torula*; and the results are in accord with what we know of other yeasts. For example, an acidification with lactic acid bacteria is used in distilleries to prevent the growth of injurious bacteria; but the amount of acidity present in the mash, about 1.1 per cent., does not prevent the *subsequent* growth of the yeast.

A final experiment on the influence of acid and temperature on this *Torula* was made by growing the *Torula* in whey containing 1 per cent.

lactic acid, at temperatures of 20°, 25°, and 37° C.

Average of Two Tests.	20° C.	25° C.	37° C.
Original number in flask per c. c	3	1	1
Six hours after	5	4	72
Nine hours after	5	15	350
Twelve hours after	93	290	2950

With the optimum (or best) temperature (37° C. and 98.6° F.), the growth was very rapid, and fully accounts for the strong development of the bitter flavor under factory conditions.

We conclude, then, that the development of acid in milk or curd, whether by the regular process of souring, the addition of a starter, or inoculation with the lactic acid bacillus, does not destroy the torula, nor remove its injurious effects. (The non-scientific reader will please turn to page 18.)

In the above account of the *Torula amara*, I have emphasized the economic importance of the organism, and the injury it causes when present in cheese; but it has a very vigorous action on milk sugar also; and organisms possessing this power are not very common, especially if we exclude the yeasts which have been described as occurring in Koumiss and Kephir granules. Pirotta and Riboni (19) in 1879 described a yeast which fermented milk sugar, and named it *Sach. galactocola*; but the description, in accordance with the methods then in use, is not sufficiently exact to enable us to identify the species.

Duclaux (20) obtained a lactose fermenting yeast from milk which was fermented. This species converted all the lactose present into alcohol and did not coagulate the milk but made it viscous, and had a strong anaerobic tendency. Duclaux was unable to isolate an enzyme, and suggested that the yeast acted directly through its growth, and not by the secretion of an enzyme.

Adametz (21) described under the name *Sach. lactis*, a species which he thought different from Duclaux's (22); but the latter author was rather sceptical about its being a new species, and thought it was the same one as he had found.

Subsequently, Kaiser (23) having found a lactose fermenting yeast, made a comparative study of the three varieties, and came to the conclusion that his species was intermediate between the species described by Duclaux and Adametz.

Grotenfelt (24) and Wiegmann (25) also described lactose fermenting yeast, but they did not describe them sufficiently for subsequent recognition.

Beyerinck (26) in 1899 isolated two yeasts, one from Kephir, which he named *Sach. Kefir*, and one from Edam cheese, *Sach Tyriocola* which fermented milk sugar and produced alcohol; and he further isolated from them an invertive enzyme which he called "lactase", which he found had the power of inverting the milk sugar, and cane sugar but not maltose.

This conclusion was, however, contradicted by Schnurmans-Stekhoven (27), who was unable to invert milk sugar with the enzyme "lactase"; and afterwards de Freudenreich (28) came to the same conclusion.

Bochiocchio (29) has also isolated a top fermenting yeast from Grana cheese, which produces blisters on the cheese. This form coagulates milk with partial peptonization, and produces an agreeable foaming beverage when grown in whey.

Jorgensen (30) isolated a true *Saccharomycete* from Kephir, which produces about 1 per cent. of alcohol in the course of 8 days. This species he named *Sach. fragilis*, on account of the feeble powers of resistance of the cell wall. It produces oval spores, which are soon set free. So far as I am aware, this is the only species of lactose fermenting yeast yet discovered which is a true *Saccharomycete*.

Duclaux (31) who reviewed the lactose fermenting yeasts in 1900, came to the conclusion that the only three yeasts which fermented sugar (milk sugar) were those isolated by himself, Adametz, and Kaiser. Those subsequently isolated are either insufficiently described, and consequently one cannot say whether they are new species or not; or else they simply assimilate the lactose and burn it in contact with the air.

The *Torula amara* ferments milk perfectly, even when oxygen is not present. Cultures were grown in whey bouillon in an atmosphere of hydrogen, and the sugar of the medium was fermented. In ordinary whey cultures, the sugar is completely fermented, as the following experiment shows:

Whey containing 37.65 grams of sugar per litre before fermentation, gave no trace of sugar (Fehling's solution) after eight days' growth; and the fermented solution was found to contain nearly 3 per cent of alcohol.

Kaiser suggested that certain of the lactose fermenting yeasts might be of economic importance; and on account of the complete fermentation of sugar by the *Torula amara*, it might, we presume, be used in the manufacture of alcohol from whey.

BITTER CHEESE EXPERIMENTALLY PRODUCED.

A peculiarity about some of the bacteria that produce bitter milk is that the bitter taste disappears when the milk is made into cheese; but the *Torula amara* produce bitter milk and bitter cheese also. We made several cheese, using cultures of the *Torula*, and the cheese thus made were very bitter.

The cultures used in the first experiments were made by breaking

up a small piece of cheese in sterilized milk, and leaving this for 24 hours at a temperature of about 85° C. The cultures thus secured naturally contained a variety of micro-organisms, probably in somewhat the same ratio to one another as would be met with at the factory. Two pounds of this culture was added to 115 pounds of milk, and left in it for 65 minutes before setting.

The curd developed slowly before dipping, but afterwards worked very fast, and had more than the usual amount of acid present at times of milling and salting—0.9 per cent. and 1.143 per cent. acid respectively. The curd was somewhat gassy, and the flavor bad, both at the time of making and subsequently, when the cheese was scored by competent judges. The total score was 76 per cent., flavor receiving only 25 points out of 40.

Subsequently several cheeses were made with pure cultures infected by the bitter *Torula*. In these cases, the flavor was not absolutely identical with that of the cheese from the factory referred to; but this is not to be wondered at when we remember that the ratio of the organisms to one another in the experiments was not identical with the ratio under the ordinary factory conditions; but, in every case, the product made was bitter and disagreeable, and the aromatic flavor noticeable on the vats of the factory was always present to a greater or less extent.

The scoring of these cheese was as follows:

				Max. 100.			Max. 40.
Cheese No. 1,	total	score	....	59.	Points for	flavor	 15
" " 2,	"	"	....	74.	"	"	 22
" " 3,	"	"	....	76.	"	"	 24
" " 4,	"	"	....	66.	"	"	 20

BACTERIOLOGICAL DATA.

A large number of analyses of experimental cheese were made, and the results from all of them were fairly constant; as a sample of these results the following quantitative analyses will serve:

Cheese made September 24th, 1901, two per cent. of a culture of the bitter organism used.

Age of Cheese.	Lactic Acid Bacteria. Per gram.	Bitter <i>Torula</i> . Per gram.
7 days	150,000,000	72,000,000
28 "	28,000,000	19,000,000
42 "	11,500,000	3,200,000
71 "	864,000	388,000

The judges reported this cheese to be very bitter and undesirable. Score for flavor, 22 out of 40.

Cheese made October 12th, 1901, two per cent. of a culture of the bitter organism used. Very little acid developed during the making, but

.495 per cent. was present at time of milling. A strong bitter flavor and aromatic "apple pomace" odor were perceptible at the time of making.

Age of Cheese.	Lactic Acid Bacteria. Per gram.	Bitter Torula. Per gram.
7 days	119,000,000	85,000,000
20 "	55,000,000	7,500,000
30 "	51,000,000	3,800,000
42 "	43,000,000	1,665,000

Score for flavor, 15 out of 40. Total score, 59 per cent

In order to study the cheese made at the factory, three were brought to Guelph, one of which was placed in cold-storage at an average temperature of 39° F., and the other two were put into the ordinary curing-room. The cheese exhibited a fair sample of the trouble complained of at the factory,—they were quite bitter.

Cold Storage Cheese :

Age.	Lactic Acid Bacteria. Per gram.	Bitter Torula. Per gram.
28 days.	342,000,000	3,200,000
42 "	271,000,000	1,570,000
90 "	48,600,000	162,000

Left in the ordinary curing-room :

No. of Days.	Lactic Acid Bacteria. Per gram.	Bitter Torula. Per gram.
28	59,000,000	960,000
Oct. 21. 42	38,400,000	800,000
Dec. 4. 90	5,184,000	58,000

The judges considered that the refrigerator cheese was superior in flavor to the cheese in the ordinary curing-room, although both were made from the same vat.

The bacteriological results show that a larger number of yeasts were present in the cold-storage cheese, and the number of acid bacteria present was also greater. When we take into account the proportion between the acid forms and the yeast, we notice that in the cold-storage cheese the ratio at 42 days was 1:147, and in the ordinary curing-room, 1:48. At 90 days, it was 1:300 and 1:90, respectively. Thus the proportion of bitter yeast to lactic acid bacteria was much greater in the cheese kept in the ordinary curing-room; and this may possibly account for the difference in the flavor noticed by the judges, although the refrigerator cheese could not be called good, as the bitter flavor was quite noticeable.

To some, however, it may seem that the number and proportion of the bitter torula to the lactic acid bacteria was out of all proportion to the effect produced; in other words, that there were too few of the bitter

torula to produce so much bitterness and bad flavor in the cheese. We must remember, however, that the torula is fully 20 times as large as the lactic acid bacterium; and we may assume that the changes brought about by the torula were in proportion to its size.

Several analyses of curd taken from the factory, just before putting to press, gave as many as 21,000,000 torula per gram; and taking into account the comparatively large size of the organism we see that these results are quite in accord with the bad flavor produced in the cheese.

BUTTER EXPERIMENTS.

Professor Dean suggested that if the factory was turned into a creamery for a season or two, the bitter flavor might disappear; but before suggesting that course, we thought it advisable to conduct a few experiments to determine the action of the bitter torula on cream, and its subsequent action on butter.

The experiments on the effect of the bitter torula were made with both sterilized and pasteurized cream.

STERILIZED CREAM. The lot of sterilized cream was ripened with a starter composed of a culture of lactic acid bacteria and a culture of the bitter torula in equal proportions; 15 per cent. of this mixed culture was used, and the cream was ripened at 22° C. (70° F.) for 18 hours. The acidity at churning time was 0.72 per cent., and the taste was sour and bitter. The cream was cooled and churned. The butter in the granular stage was of good appearance; but somewhat spongy. Two days after making, the sample was scored by an expert judge, who gave it 32 points out of 45 for flavor; and he remarked that the butter had a flat, tallowy taste, without butter aroma.

PASTEURIZED CREAM. The lot of pasteurized cream (160° F.) was ripened with a starter containing the bitter torula, for 12 hours, at 68° F. Very slight acidity developed, but the sample churned easily in 18 minutes. The granular butter was very pale in appearance, had an aromatic odor, and a nauseating, bitter, astringent taste. It would be impossible to sell such butter in any market.

Subsequently several churnings were made as detailed above; and in every case the butter was very bad, and had a pronounced, bitter, disagreeable taste.

These experiments show that the trouble cannot be got rid of by changing from cheese-making to butter-making for a time.

The majority of summer creameries in this Province do not pasteurize their milk; and where pasteurization is not done, there is danger of trouble from bitter organism, especially if the skim-milk is returned to patrons in the cans in which the whole milk is conveyed to the factory; and the danger is the same whether the factory is used for making butter or cheese.

SUMMARY

f the bacteriological analyses of stable air, fore-milk, can washings, and mixed milk of 96 patrons of the K— factory.

Bitter Tcrula ; L, Lactic acid bacillus ; C, Bacillus coli ; A, Bacillus lactis aerogenes ; S, The hay bacillus ; O, other yeasts than the bitter one
Y, Ropy milk bacillus ; M, Moulds ; R, Red mould ; X, Harmless bacteria ; P, Proteus group.

Stable, clean, + ; dirty, —; ventilation, etc.	Germ content of stable air.	Germ con- tent of fore-milk.	Condition of cans, where kept, etc.	Germ content of can-washings.	Germ content of mixed milk.
+	M— only a few	L	good, left long before washing	T, O, G, etc.	T, O, A, G, L, etc.
—	M, R, etc.	L	near fruit trees.	T, O, A, & C, etc. ...	T & O (1,000,000 per c.c.) S, A, C.
—	M, R, C, etc.	L & X	"	T, O, S.	T & O (8,000,000 per c.c.) C, A.
—	M, R, P, & O.	L & X	old and rusty, trees.	T, O, S, etc.	T, 125,000, A, 50,000.
— and badly lighted.	M, R, C, & Y.	L	near barnyard.	O, Y, etc.	T, O, C, A, 15,000 S, etc.
+	M & C.	L & X	under apple trees.	T, O, etc.	T, O, A, 150,000, S.
— and very dark.	M, C, & P.	L, etc.	under fruit trees.	T, O, S, etc.	T, O, C, 100,000 & A, 200,000.
— and dark.	M, 5 species, R & C.	L & X	under apple tree.	O, etc.	O, A, 800,000, P & R.
Milked in yard which was dusty.	M & C. ....	.....	under hops and near barnyard	T, O, S, etc.	T, O, A, C, S, etc.
—, +	M, R, C.	L	old, rusty, and near trees.	T, O, S.	T, O, C, A, etc.
—	M, R, C, & S.	L, etc.	under fruit trees.	T, O, S, etc.	T, O, A, etc.
—	M, R, C, & P. ....	.....	close to barnyard.	T, O, etc.	T, 600,000, C, A, etc.
Milked in yard.	M & C.	L, etc.	close to road and pig-pen.	T, S, C, etc.	T, A, 125,000, C, 5,000,000, etc.
—	M, C, & O.	L & X	near fruit trees.	T, O, S, C, etc.	T, 1,000,000, O, A, 600,000 & C.
+; —	M, C, & C.	L	under maple tree.	T, O, S, etc.	T, O, C, A, & R.
—	M & C.	L & X	"	T, S, A, etc.	T, 2,000,000, O, A, 400,000 & C.
Milked in yard.	C & P. ....	.....	near barnyard.	T, O, etc.	T, O, C, & A.
—	M, R, & C.	L, etc.	near barnyard and trees.	T, O, very few bacteria	T, O, C, A, S, etc.
Milked in yard.	M, R, & C. ....	.....	near apple trees.	T, O, etc.	T, O, 200,000, S, etc.
—	M, P, few.	L	in barnyard.	T, S, etc.	T, 400,000, etc.
Milked in orchard.	M, C, & P.	L & X	under fruit trees.	T, & O, enormous Nos	T & O, 1,400,000, & C.
+	M, C, & P.	L, etc.	by roadside.	T, O, etc.	T, O, 100,000, & C.
—	M, C, & P. ....	.....	" .....	T, O, etc.	T, O, 400,000, A, C, etc.
—	M, C, & P. ....	.....	in barnyard.	T, O, etc.	T, O, C, S, & R.
—	M, C, & P. ....	.....	near barnyard, under maples	T, O, many S.	T, O, C, & A, 100,000.
Milked in yard.	M, R, & P. ....	.....	under fruit trees.	T, O, etc.	T, O, C, & A.
—; +	M, C, & P. ....	.....	under trees.	T, O, etc.	T, O, 3 species, C, & A.
—	M & C. ....	.....	in barnyard.	S, C, etc.	S, O, etc.
—	M & C. ....	.....	under trees.	T, O, etc.	T, O, C, etc.

30	—, chicken dirt.....	M & C, very many	under maple tree	T, O, S, etc	& O, 100,000, C & P.
31	— and dark	M, R, C, & P.	under maple and poplar trees	T, O, S, C, etc	T, & O, 100,000, C & A.
32	Milked in yard	M, R, C, & P.	near trees	T, O, S, etc	T, 50,000, C, 100,000, A, etc.
33	—	M, R, C, & P.	near barn	T, Y, S, etc	T, 5,000, C & A, 400,000.
34	Milked in yard		under maple tree	T, etc.	T, A, & S.
35	Milked in yard		“	T, etc.	T, C, & A.
36	—	M, R, & C.	under fruit trees	T, O, etc	T, O, C, A, S, & R.
37	—	M & C.	under fruit or maple	T, O, S, etc	T, O, A, C, etc.
38	—	M & C.	under trees	T, very few, etc	T, A, S, P, & R.
39	Milked in lane		stand under maple	T, O, very numerous.	T, O, A, & P.
40	—; +	M, R, & C.	“	T, O, very numerous.	T, O, A, C, & R.
41	—; +	M & P.	under fruit trees	T, very few, S, & Y	T, O, A, & R.
42	—	M, C, P, etc.	“	T, O, etc	T, O, C, & A.
43	— and ventilation bad	M, C, & R.	bad cans, under maple trees.	T, O, numerous	T, O, A, S, & R.
44	—; +	M, C, & P.	near a vine	T, O, S	T, O, S, & A, 100,000.
45	Milked in yard		under fruit trees	T, O, S, etc.	T, & O, 1,500,000, & A. O.
46	—	M, R, & C.	cans dirty	T, O, S, & P	T, & O, 2,500,000, A, & C.
47	— and ventilation bad	M & C.	under vine and maple	T, O, etc	T, & C, 1,600,000, etc.
48	—	M & C.	left long without washing	T, & S, very numerous	T, 400,000, S, A, etc.
49	—	M	in a wooden trough	T, S, etc	T, O, S, C, & R.
50	—; +	M & C.	under trees	T, O, S, etc	T, O, S, C, & R.
51	Milked in lane	P & C.	near vine	T, O, etc	T, & O, 400,000, C, & S.
52	—		cans dusty	T, O, etc	T, & O, 2,000,000, C, & S.
53	Milked in lane		left long without washing	T, O, S, etc	T, O, 3 species, C, A, & S.
54	Milked in lane	M & C.	dirty cans	T, O, etc	T, O, C, A, etc.
55	—	M & C, & P.	near stable	T, O, etc. Pails, only	T, O, C, A, etc.
56	—		left long without washing	bacteria	T, 50,000, C, 100,000.
57	—	M, C, & P.	left lying on ground	T, M, etc	T, O, C, & A, 200,000.
58	—	M & C.	near fruit trees	T, etc	T, C, & A, 150,000.
59	Smell from piggery	M & C.	near the lane	T, O, S, etc., also pails	T, O, C, A, & R.
60	—	M	under an apple tree	T, S, pails, S, etc.	T, O, C, & A.
61	—	M & C.	under poplars	T, etc., pails too.	T, & O, 2,500,000, C, & A.
62	—	M	under vine	T, S, etc	T, & O, 1,500,000, C, & A.
63	Smell from swine	M, R, C, & P.	cans contained rain water	T, S, etc	T, C, P, & S.
64	—	M & C.	under maple trees	T, O, etc., pails, no	T, C, & A.
65	—, and ventilation bad	M, C, & P, numerous.	under poplar	yeasts	T, C, A, P, & R.
66	Milked in lane		milk sieve dirty	T, O, etc.	T, C, A, C, 250,000, etc.
67	—	M, R, P, etc.	kept in trough	T, O, pails, T and S	T, 5,000, C, & A, 1,200,000.
68	—	C & M.	left long before washing	T, S, etc	T, 300,000, & etc.
69	—, and ventilation bad	M & C.	lying in grass	T, & O	T, A, & P.
70	—	M, R, P.	not clean, near trees	T, etc	T, O, & A.
71	—	M, R, & C.	under fruit, near stable	T, O, S, P, & C	E, S, C, A, etc.
72	—; +	M, P, & C.	under fruit trees	T, O, etcj	T, O, 2,200,000, C, A, etc.
73	Milked in lane		under fruit trees	T, O, etc	T, O, C

SUMMARY

Of the bacteriological analyses of stable air, fore-milk, can washings, and mixed milk, etc.—Continued.

Bitter Torula : L, Lactic acid bacillus ; C, Bacillus coli ; A, Bacillus lactis aerogenes ; S, The hay bacillus ; O, Other yeasts than the bitter one ; Y, Ropy milk bacillus ; M, Moulds ; R, Red mould ; X, Harmless bacteria ; P, Proteus group.

Stable, clean, + ; dirty, — ; ventilation, etc.	Germ content of stable air.	Germ content of fore-milk.	Condition of cans, where kept, etc.	Germ content of can-washings.	Germ content of mixed milk.
—	M, P, & C		under poplar trees	T, etc	T, O, C, S, etc.
+	C, few		in the lane	T, O, S, etc	T, O, C, A, & P.
+	M, P, etc		under maple trees	T, etc.	T, C, & R.
—	M, C, & P		on grass	T, S, etc	T, O, A, & C.
Ventilation bad	M, C, & P		on the milk stand	T, O, S, etc	T, A, C, & R.
— ; +	M, R, & C		cans dusty, under maple	T, O, etc	T, O, A, & C.
+	M		between house and stable	T, O, S, C, etc	T, O, A, C, etc.
+	M & P		under basswood		

In the cases of the following patrons, the mixed milk only was examined.

- The bitter torula, another yeast and B. coli.
“ “ “
“ “ two yeasts and Red mould.
“ “ B. coli and a capsulated bacillus.
“ “ B. subtilis, and B. coli.
“ “ Oidium lactis, B. subtilis, and a capsule bacillus.
Two species of yeast, B. lactis aerogenes, and Red mould.

The milk from all these patrons contained one or two species of yeasts, B. coli, or B. lactis aerogenes, or both were present in all samples.

The above tables summarize as briefly as possible the results of personal visits to the patrons of the factory, and the bacteriological analyses of fore-milk, stable air, can washings, and the mixed milk of each herd.

I regret to say that the stables were very generally dirty, the beams and ceilings being covered with dust and cobwebs ; and in a number of cases, the floors, stanchions, etc. were fouled with the droppings of cattle or poultry. In such cases, the stable air gave large numbers of *B. coli* and *B. lactis aerogenes*. In such stables, moulds were usually present in large numbers ; and the Red Mould, of which mention has already been made, was found in 19 stables. All the micro-organisms isolated from these dirty stable airs were unfavorable to cheese and butter making. In cases where milking was done in the barn-yard, there usually was a large infection from the Colon bacillus and other undesirable species.

Only a limited number of analyses of the fore-milk were made, as the bacterial content did not seem to warrant this line of investigation. The *B. acidi lactici* (Esten) and some slow growing harmless bacteria were isolated from the fore-milk or first milkings of about a 100 cows. In no case was the Bitter Torula present nor any representatives of the Colon group.

In view of the large sums of money which patrons receive from the factory, it is astonishing that little or no effect has been made to provide proper places for keeping the milk. The only general precaution taken is to cover the can with a wire screen to keep out the cats ! and in many cases the place selected for the can is most unsuitable. The patrons, as a rule, seem quite unaware of the possibilities of infection from road-dust and barnyard air ; and they do not understand the importance of controlling the temperature.

The huge numbers bacteria and the great diversity of species found in the can washings were very noticeable throughout our investigations. The Bitter Torula was present in all samples but two ; and in one of these, the farmer did not draw the whey home in his milk can but used another vessel. I have elsewhere dwelt on the difficulty of washing the cans properly on the farm ; and from the bacteriological evidence here presented, we are quite safe in saying that when the milk cans are once thoroughly infected with micro-organisms, it is almost impossible to kill these organisms by the methods of can washing generally practised on the farms of this Province. We should not, however, lose sight of the fact that the more thorough the washing, the less the liability of infection from undesirable bacteria.

The mixed milk of the different patrons contained the bitter organisms in varying numbers. In some, very few torulae were present ; in others, they existed in enormous numbers. In samples of whey taken from the vats, there were large numbers ; and it is evident that these organisms carried back in the whey became a permanent source of infection. They may in fact be described as endemic (produced by or depending

upon special local conditions) in this district. Hence, even if the cans are washed and sterilized, there may occur conditions which will produce a recurrence of the trouble.

The cheesemaker of the neighboring factory (who washes and sterilizes the milk cans in the factory) informed me that on one or two, occasions during the summer bitter milk was delivered at his factory; and he added "we should undoubtedly have had serious trouble, had it not been for the fact that we wash and *sterilize* all milk cans in the factory."

In addition to the bitter torula, the Colon group of bacteria were well represented; and they are most undesirable for the maker, as they give rise to gas and disagreeable flavors, and in colored cheese produce mottles. Certain bacteria belonging to the *B. lactis aerogenes* group also produce a somewhat bitter taste in milk; and these add slightly to the bitterness produced by the *Torula amara*.

A bacillus producing slimy milk was also occasionally found in the can washings and stable air, a fact which shows that bacteria of this class are rather wide-spread; and, given certain conditions, an epidemic of slimy milk may occur. Nothing more concerning this germ need be said in this connection, as the habitat and characteristics of slime-producing bacteria will be the subject of a future publication.

REMEDIAL MEASURES.

The inquiry into the condition of the stables, cans, pails, etc. of the patrons of the K—— factory together with the bacteriological evidence above related, show that certain measures should be taken in order to remedy the present condition of affairs.

The dominant note sounded at the recent Dairymen's Convention was *better care of milk*; for unless this care is given, it is impossible for the butter or cheese-maker to produce a prime article. According to many speakers and writers, the time has come when contracts should be made between the milk producer and the factory executive; and these contracts should contain provisions for the exclusion of fowl and swine from cow stables, the care of stables so as to avoid the accumulation of dust, cobwebs, etc., the whitewashing of stables twice a year, cleanliness, in milking, efficient aeration and cooling, proper places for keeping the milk, the delivery of the milk at the factory at a certain temperature, and the proper washing of utensils. Should these improvements be made, I am sure that the results would surprise all concerned; and the little extra care involved would be amply repaid by the higher price of cheese made from milk handled in a careful, sanitary manner; for it is well known that buyers discriminate and place considerable emphasis on the reputation of a factory; and they would, we think, quickly notice the merits of such a system as that suggested.

In order to get rid of the bitter *Torula* at the K—— factory, and improve the general conditions under which the milk is produced, mea-

asures should be taken to remedy defects as regards—

1. The stables.
2. The cans, pails, and utensils.
3. The control of the temperature.
4. The places in which the cans are kept before and after the milk is put into them.

1. THE STABLES. The bacteria existing in the air of most of the stables are very undesirable, especially those whose habitat is in the manure, dried particles of which are wafted about in the building by the slightest currents of air and fall into the milk pails during milking, and during straining when the cans are kept in the stable or close to the barnyard.

Stables should be kept clean (as free as possible from cobwebs and accumulations of dust), and be whitewashed twice a year, once in the fall and again in the spring when the cows are put out to pasture. The whitewash should be made from fresh lime; and after slaking, a wash of about the consistency of cream should be made, strained through a piece of sack-ing, and applied by means of a brush or ordinary spray-pump. In the latter case, two or more applications are necessary each time. A little molasses, size, or Portland cement added to the whitewash increases the adhesiveness. In case disinfection is thought to be necessary, crude car-bolic acid may be used in the proportion of a pint to every gallon of whitewash.

Whitewashing not only decreases the bacterial infection; but it in-creases the amount of light in stables, thus directly promoting the health of the stock.

THE CARE OF CANS, PAILS, STRAINERS, ETC. Nothing is more diffi-cult to clean properly than cans, pails, strainers, etc., with the facilities at hand on the average farm. No matter how hard the good housewife may scrub the can, she will rarely succeed in cleansing it so thoroughly that it will be free from bacterial life. A solution of soda is commonly used, and it is effective in removing grease and other forms of dirt; but it has very little germicidal value. Even a four per cent solution is of little use as a germicide. The final scalding with hot water (one cannot say boiling water) is insufficient to kill the bacteria on the inner surface of the can and in the cracks and crevices which are usually present (see page 6). Steam, the best means of sterilizing cans, is not available on the farm. Hence the proper place for cleaning cans is at the factory, where all appliances are at hand for doing the work thoroughly and ex-peditiously. So far as we can see, this is the first step, and a very im-portant one, towards the removal of the trouble from the bitter *Torula* and other injurious organisms. Let all cans be thoroughly washed and *sterilized* before they leave the factory; and then let the factory insist, and see to it, that those in charge of the work on the farms supplying milk, (1) wash and scrub thoroughly (and occasionally scour) all pails,

strainers, dippers, and other utensils used in handling the milk ; (2) rinse all pails, strainers, dippers, etc., thoroughly with *boiling* water immediately before using ; and (3) rinse the cans out thoroughly with *boiling* water a few minutes before putting the milk into them.

The practice of carrying ordinary, unpasteurized whey in milk cans from the factory to the farm cannot be too strongly condemned. So long as it is done, so long will there be trouble and serious loss from undesirable taints and flavors in milk ; and the surprising thing is that good factories tolerate the practice. Let the whey be taken back in a can kept for the purpose ; or, if that cannot be done, let all the whey be pasteurized at the factory by using the exhaust steam from the engine.

Utensils should be cleaned at the farm in the following manner : First, wash with water ; then scrub well with a *hot* soda solution, using about two per cent. of soda (powdered concentrated ammonia may be used instead of soda) ; next empty out the soda washings, and scald with

I

A single germ.



Progeny of a single germ in 12 hours in milk cooled with cold water.



Progeny of a single germ in 12 hours in milk allowed to cool naturally.

FIG. 6.—Showing the effect of cooling milk on the growth of bacteria. The beneficial results of early chilling are manifest. (After Russell.)

boiling water ; lastly empty the water out and allow the can to drain dry. Provide, if possible, some kind of cheap rack, to set the cans on, at an angle of about 45 degrees. On such a rack, the cans will dry out nicely and will not be much exposed to infection from dust, falling leaves, etc.

Do not, on any account, leave the water in the can ; and do not use cloths or brushes in the final rinsing with the boiling water.

MILKING. The cows, before being turned out in the spring should have their flanks, udders, and tails well clipped. If before milking, the udder of the cow is rubbed with a damp cloth, the germs which are present on the hairy coat of the animal are prevented from falling off into the milk pail, as bacteria cannot leave a moist surface. Milking

should always be done with clean, dry hands. Immediately after milking, the milk should be strained through a brass wire sieve, with several thicknesses of cheese-cloth on it, or, better, a woollen cloth; but these cloths must be carefully cared for and rinsed in boiling water *every day*. If they are not so cared for, their use should be dispensed with, as neglected cloths are an undoubted source of infection.

AERATION AND COOLING. Aeration and cooling are both very desirable. I have already spoken of the effect of temperature on the growth of the bitter *Torula*; and the following figures show the rate of growth of a single germ:

Temperature.	Rate of Growth of a Single Germ.				
	2 hrs.	3 hrs.	4 hrs.	5 hrs.	6 hrs.
54° F.	4	6	8	26	435
97° F.	23	60	215	1830	3800

A reference to Fig. 6 will show the beneficial effect of early cooling; and I am strongly of the opinion that, if the milk is cooled sufficiently, the trouble from the bitter *Torula* will be largely overcome.

The Copenhagen Milk Company require that the milk be cooled to 40° F. at the farm, and that when delivered at the city establishment, it shall not be more than 50° F. These figures are possibly too low for ordinary factory practice; but, if the milk were cooled even to 60° F. at the farm, or to a temperature, say, two degrees above that of the water supply, it would be a great benefit.

Most of the best coolers aerate as well as cool, and those properly constructed should cool the milk to a temperature of two degrees above that of the water used for cooling. Should the farmers be unwilling to incur the expense of buying coolers, an arrangement might be made, as at Copenhagen, Denmark, by which the factory would let coolers out on hire. These coolers, made of copper tinned over, are practically indestructible. With ordinary care, they last for ten or more years, and when the tin wears off they can be replated.

Most farmers now have windmills for pumping water, and a connection could be made with a barrel or tank suitably placed; and necessary, ice could be used in the barrel.

PLACE FOR MILKING. Throughout this bulletin, I have emphasized the fact that most patrons keep their milk cans, both before and after filling, in very unsuitable places, where there is constant danger of infection from harmful bacteria or from the absorption of objectionable odors.

The factory management should clearly and strongly forbid the following practices:

- (1) The keeping of uncovered cans under trees.
- (2) The keeping of uncovered cans near stables, piggeries, or barnyards.
- (3) The keeping of cans for more than short periods on milkstands by the roadside.

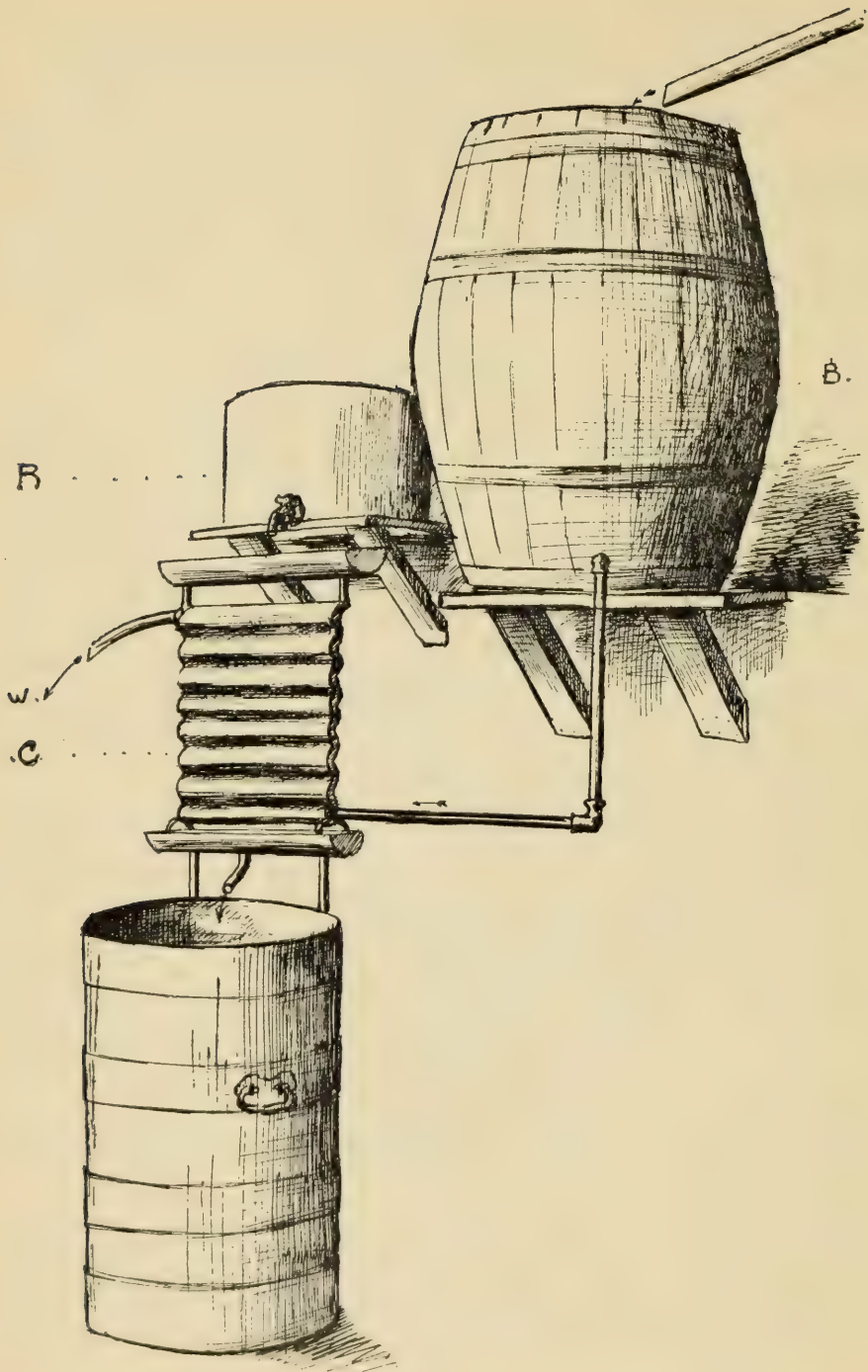


FIG. 7.—COOLING AND AERATING APPARATUS.

B. Barrel filled with cold water from well.

R. Reservoir to hold contents of milk pails.

C. Cooler and aerator. The milk passes over the corrugations.

W. Waste water pipe from the cooler. The water enters below on the right side and passes out at *W*.

Every farmer engaged in milk production should have a room in which to cool and aerate the milk immediately after milking, and to keep the filled cans until the time of putting them on the stand for the drawer to collect. This room need not be large or expensive, and it should be convenient to the stable or place of milking; but in no case should it be placed where there is a liability of infection from barnyard dust, or where the milk is in danger of absorbing stable, barnyard, or piggery odors. It should be sheltered from the prevailing wind. A lean-to against a building often serves the purpose very well.

In this room, there should be space for the milk cooler and accessory apparatus, a spring weigh scale, and a requisite number of milk cans, a strainer, pails, etc.; and the milk, taken there immediately after milking, should be strained, and at once emptied into the tank above the cooler. In this way, the cooling and aeration would be finished a few minutes after the last pail of milk was drawn. Fig. 7 conveys some idea of what the interior of such a room should be like.

REFERENCES.

1. *Robertson, J. W.*—Report of the Dairymen's Association of Ontario, 1900, p. 39.
2. *Pasteur.*—Compt. Rendus lii, 1861. Ann. de Chemie et de Phys., 1860.
3. *Meissl.*—Sur les alterations de la caseine du lait. Bull. Soc. Chem. de Paris, xxxix, 1883, p. 556.
4. *Loew.*—Sur les alterations du lait conservé. Bull. Soc. Chem. de Paris, xxxix, 1883, p. 557.
5. *Duclaux.*—Fabrication, maturation, et maladies du fromage de Cantal. Annales agronomiques, 1878.
6. *Nägeli.*—Theorie der Gährung, München, 1879, p. 103.
7. *Liebscher.*—Wiener landw. Zeitung, 1883, quoted from Kramer, Die Bakteriologie in ihren beziehungen z. Landwirtschaft, Wein, 1892.
8. *Hueppe.*—Untersuch. über die Zersetzung der milch durch mikro-organismen. Mitth. a. d. K. reichs Gesundheit's, 11 Berlin, 1884, p. 309.
9. *Loeffler.*—Berlin Klin. Wochen., 1887, s. 630.
10. *Kruegger.*—Molkerei Zeitung, 1890, nr. 30, quoted from Kramer, loc. cit.
11. *Weigmann.*—Milch Zeitung, 1890, p. 881.
12. *Conn.*—Ueber einen bittere Milch erzeugenden micrococcus. Centralb. f. Bakt. ix. p. 653, 1891. Storr's Agr. Expt. Sta. Report, 1890, p. 158.
13. *Hueppe.*—Ueber Milch sterilisierung und über bittere milch mit besonderer Rücksicht auf die kindernahrung. Berl. Klin. Woch. xxviii, 1891, s. 717-721.
14. *Bleisch.*—Zeitschrift f. Hyg. xii, p. 81, 1893.
15. *de Freudenreich.*—Ann. de Micrographie vii, p. 1, 1895.
16. *O'Callaghan.*—New South Wales Agr. Gaz., Vol. 10, p. 882, 1899.
17. *Cavara.*—Saccharomyces Comesii. Revue Mycologique, 1893.
18. *Gronlund.*—En ny Torula art og to nye Saccharomyces Arter. Vidensk. Medd. fra den Natur. Forening. Kjöbenhavn, 1892.

19. *Pirotta and Riboni*.—Rendiconti d. R. Istituto Lombardo, 1879.
 20. *Duclaux*.—Fermentation alcooliques du sucre du lait. Ann. de l'Inst. Past. 1, 1887, p. 573.
 21. *Adametz*.—Saccharomyces lactis eine neue milchzucker vergahrende. Hefeart. Centralb. f. Bakt., V. 1889, p. 116.
 22. *Duclaux*. Revue critique. Ann. de l'Inst. Past. 1889, p. 201.
 23. *Kayser*.—Levures alcooliques de lactose. Ann. de l'Inst. Past., V., p. 395, 1891.
 24. *Grotenfelt*.—Milch Zeit., 1891, p. 759.
 25. *Weigmann*.—Milch Zeitung, 1890, p. 743.
 26. *Bejerinck*.—Arch. Neerland, xxiii, 1889, p. 428.
Centralb. f. Bakt., 1889, p. 44.
 27. *Schuurmans-Steekhoven*.—Saccharomyces Kefir. Diss. inaug., Utrecht, 1891.
 28. *de Freudenreich*.—Bacteriol. Untersuch. über den Kefir. Centralb. f. Bakt. abt, II, iii, 47, 1897.
 29. *Bochiocchio*.—Contribution a l'etude de la fermentation de la lactose. Ann. de Micr., vi., p. 165.
 30. *Jorgensen*.—Micro-organisms and fermentation, London, 1900, p. 214.
 31. *Duclaux*.—Traité de Bacteriologie, Vol. iii, 1900.
-

CP30/2117 2
13121

ONTARIO AGRICULTURAL COLLEGE

BULLETIN 121.

RIPENING OF CHEESE IN COLD-STORAGE

COMPARED WITH

RIPENING IN THE ORDINARY CURING-ROOM.

—BY—

PROFS. H. H. DEAN, F. C. HARRISON, AND R. HARCOURT.

ONTARIO AGRICULTURAL COLLEGE, GUELPH.

PUBLISHED BY
THE ONTARIO DEPARTMENT OF AGRICULTURE, TORONTO.
TORONTO, ONT., JUNE, 1902.

Ontario Agricultural College and Experimental Farm.

RIPENING OF CHEESE IN COLD-STORAGE COMPARED WITH
RIPENING IN THE ORDINARY CURING-ROOM.

BY PROFS. H. H. DEAN, F. C. HARRISON, AND R. HARCOURT.

Since the British market demanded a "fatter" cheese, or a cheese with softer body and texture, Canadian cheesemakers have been endeavoring to meet the demand with indifferent success, because the average ripening (or curing) room at the factory is not adapted to holding such cheese for any length of time. In hot weather, the temperature rises in the ripening-room with the rise of temperature outside. As a consequence, the cheese "go off" in flavor, and in many cases develop a mealy texture. To overcome these difficulties, better constructed ripening-rooms and better means of cooling them have been advocated, and improvements in these directions have been made by a number of factories; but the majority are not yet in a position to make cheese with softer body. The labor of bringing ice to the ripening-room and putting it into the ice-boxes makes this method very expensive. The sub-earth duct has given fairly good satisfaction as a means of cooling the air in a properly insulated room; but it does not maintain the temperature much below 65° to 70° F.

Recently there has been a movement in favor of central, or consolidated, cold-storage ripening (curing) stations. This plan has at least two things to recommend it: (1) it keeps the cheese safe from the effects of heat; (2) it enables buyers to do their work at very much less expense for inspecting the cheese. The disadvantages are: (1) the expense of operating such stations; (2) the expense of shipping to them; and (3) the fact that, under such a system, the cheese are to some extent out of the hands of the salesmen—though there is no reason why one salesman should not act for several factories, instead of each factory having a salesman as at present. Co-operation and consolidation should be the watchwords of modern dairy enterprises. Too many small, poorly equipped factories which compete with one another for the small amount of milk in the locality, are a great injury to the Canadian cheese trade. Though we may not have co-operation and consolidation in manufacture for some time, there is no reason why we should not at once have co-operation and consolidation in ripening and selling. If this is secured the principle will probably extend to the manufacture before long.

It is estimated that the saving in loss of weight during ripening, and the improved quality and yield of the cheese, will more than pay the extra cost of maintaining central cold-storage stations. At present, we are not prepared to say that *all* cheese should be ripened in cold-storage; but we certainly think that cheese made during the hot weather, say in the months of July and August, should be placed in cold-storage as soon as possible after they are made. Once a week would be a convenient time to send all the cheese made in the hot weather to a cold-storage station. In the case of large factories, and factories not convenient to a central station, it may be advisable to have cold-storage at the factory.

The results which are given in this bulletin are to be considered as preliminary. The work is being carried on during the present year (1902); and a full report of the results will appear next year.

The experiments relating to the effect of ripening (or curing) cheese at a temperature of about 40 degrees F., compared with ripening cheese in an ordinary ripening-room for the whole period, and also compared with ripening for one, two and three weeks in an ordinary ripening-room and then removing to cold-storage, began in April, 1901, and were continued each month during the season up to and including the early part of November. The plan of the experiments was to make some cheese each month during the season, rather than a large number of cheese at one period. The number of experiments by months were: April, two; May, four; June, two; July, four; August, three; September, six; October, three, and November, two. The quantity of milk used each time varied from 1,200 to 1,570 lbs., making a total of 37,572 pounds of milk, testing an average of 3.55 per cent. fat for the season. In most of the experiments, five flat Cheddar cheese were made from each curd. In a few cases, only four cheese were made out of the vat of milk. These cheese were marked A, B, C, D, and E, and were carefully weighed when taken from the hoops.

The A cheese were put directly into ice cold-storage, where the temperature averaged 37.8°F., and the per cent. of humidity averaged 91.6° for the season. The extreme variation in the monthly average temperature of the cold-storage from April to November was 4°, and the variation in the humidity was but 4 per cent.

The other five cheese were put into the ripening-room, and transfers were subsequently made from the ripening-room to cold-storage as follows: The B cheese, at the end of one week; the C cheese, at the end of two weeks, and the D cheese, at the end of three weeks. The E cheese were left in the ripening-room and ripened in the ordinary way at an average temperature of 63.8° F. for the season. The average per cent. of humidity in this room was 79.1 for the season. The average monthly variations in the temperature of this room were from 68.6° in July to 58.7° in November. The humidity varied from 84.3 per cent. in August to 73.7 per cent. in October. The temperature of the air outside averaged

56.9° for the season. The average maximum temperature outside ranged from 85.8° in July to 39° in November.

The average minimum outside temperature ranged from 59.6° in July to 24° in November. The month of July was the hottest month of the season. August was next, with maximum and minimum averages of 79.7° and 56.3°. June averaged 77.4° and 53.5°, for maximum and minimum temperatures.

THE ACIDITY OF THE MILK, WHEY AND CHEESE.

The milk used in the experiments was partly from our own herd and partly from patrons in the neighborhood of the College, and did not differ materially from milk supplied to ordinary cheesemakers.

The amount of acid in the milk at the time of setting, in the whey at various stages in the process of manufacture, and in the cheese while curing, was determined by means of a one-tenth normal solution of potash, using phenolphthalein as an indicator. While it is known that the acidity determined in this way is partly due to acid salts and casein, the usual practice was followed of reporting it in terms of lactic acid. The average percentage of acid arrived at in this way in the milk at the time of adding the rennet, was .167. The whey at the time of dipping averaged .154, or slightly less than the milk. The whey, at the time of milling, salting and pressing, contained respectively an average for the season of .689, .924 and .860 per cent. of acid. The extreme variations in the acid of the milk were .153 to .189; in the whey at dipping, .135 to .189; at milling, .612 to .756; at salting, .855 to .990; at the time of putting to press, which was about one-half hour after the time of salting, .756 to .999. In some tests made of the whey pressed from the cheese, about one and three-quarters hours after salting, or at the time of "dressing," the percentage of acid had increased to nearly the same point as when salted, or an average of .868 per cent. The addition of salt to the curd reduced the percentage of acid in the whey. This was probably due to the expulsion of moisture from the curd by the salt. No free lactic acid was found in the cheese; yet the percentage of acid (determined by means of one-tenth normal solution of alkali, with phenolphthalein as the indicator, and calculated as lactic acid) gradually increased until it reached 1.6. Lot A, which was ripened entirely in cold-storage, developed acid more slowly than lot E.

Among other changes that take place during the ripening process, casein is rendered soluble; and in order to compare the rate at which this change is brought about in the two methods of ripening, the amount of casein which had become soluble in water was determined in a number of the cheese marked A and E.

In E cheese, about 20 per cent. of the casein was rendered soluble in between five and six weeks; and it required between five and six months for the casein in the A cheese to reach the same degree of solubility. It appears that cheese kept in a ripening-room at a temperature

of 60 to 65 degrees will ripen as much in one week as cheese in cold-storage, at a temperature of 38 to 40 degrees, will ripen in one month.

The most notable fact in the bacterial content of Cheddar cheese, is the very large numbers of lactic acid bacteria that are present. These bacteria are most numerous at the time the cheese comes from the press, and from then on their numbers gradually decrease. Others that are usually present, but in smaller numbers, are gas-producing and digesting bacteria, which have an injurious effect in the process of ripening.

In the cold-storage cheese, the lactic acid bacteria were the predominant species present, and they lived for a considerably longer time in the cold-storage cheese than in the cheese kept in the ordinary ripening-room. The decrease in the number of bacteria in cold-storage cheese, compared with the decrease in the number in cheese in the ordinary ripening room, may be graphically shown as in the following diagram:



Cheese A and E, both made from the same curd.
 ——— refrigerator cheese.
 +++++ ordinary curing room cheese.
 The numbers on top line represent age in days.

From this diagram it will be seen that on the 86th day the cold-storage cheese contained about $\frac{7}{8}$ ths of the total number of lactic acid bacteria found in it at the first analysis, whilst the ordinary ripening-room cheese contained only $\frac{1}{40}$ th of the total number. The significance of this fact is that there is little chance for undesirable bacteria to produce bad flavors in the cold-storage cheese owing to the large number of the lactic acid bacteria, the proportion of the lactic acid bacteria to certain undesirable kinds being much greater than is usual under ordinary conditions.

This point was well brought out by a series of cheese made early in the season. The ripening-room cheese was not of good flavor. Certain undesirable bacteria were present, and the ratio between the lactic acid bacteria and the undesirable ones was found to be as follows; on the

first day, 97 : 1 ; on the 14th day, 85 : 1 ; and on the 30th day, 47 : 1. On the other hand, the ratio in the refrigerator cheese was on the first day, 97 : 1, and on the 49th day about the same.

If these results are confirmed, they will be of much importance, because they tend to show that undesirable bacteria are unable to grow and give trouble in refrigerator cheese ; and hence cheese in cold storage will not likely be of any worse flavor when ripened than when it was put in the storage room ; and it is altogether probable that the cheese ripened in this way will not go " off " in flavor after it is taken out of the refrigerator, owing to the large number of desirable (or lactic acid) bacteria compared with the undesirable ones.

LOSS OF WEIGHT IN RIPENING.

The cheese put directly into cold-storage from the hoops (av. temp. 37.8° F.) lost an average of 2.1 per cent. in one month. Those put for one week into an ordinary ripening-room and then put into cold-storage lost 2.8 per cent. Those placed in cold-storage at the end of two weeks lost 3.2 per cent. in a month, and those put in at the end of three weeks lost 3.6 per cent. in the same time. Those allowed to remain in the ordinary ripening-room (average temperature 63.8°) lost 4.4 per cent. in one month. These percentages are greater than would occur with large cheese, as the cheese experimented with weighed only about 30 pounds each. However, the relative losses in weight during the ripening are fairly well expressed by the figures given. Cheese ripened at an average temperature during the season of 63.8° lost in one month more than twice as much as did smaller cheese put directly from the hoops into cold-storage at an average temperature of 37.8°. The saving in loss of weight from placing in cold-storage at the end of one week was 1.6 per per cent. ; at the end of two weeks, 1.2 per cent., and at the end of three weeks, 1.8 per cent.

The saving in weight from placing in cold-storage at the end of one week would be at least ten pounds of cheese in a factory making ten ordinary cheese per day—say \$1 per day when the price of cheese is 10 cents per pound.

QUALITY OF THE CHEESE.

All the cheese were scored according to the following scale of points : Flavor, 40 ; closeness, 15 ; even color, 15 ; texture, 20 ; finish, 10 ; total, 100. They were scored ten points for finish, in order to make the results more uniform. We are indebted to the following gentlemen for assistance in scoring : R. M. Ballantyne, A. A. Ayer, A. W. Grant, D. M. Macpherson, P. W. McLagan, and A. E. Wieland, of Montreal ; I. W. Steinhoff, Stratford ; J. B. Muir, Ingersoll ; A. T. Bell, Tavistock, and G. H. Barr, Stratford.

The following table shows the average of the first scorings, and of all scorings made by months and for the full season :

SCORINGS OF THE CHEESE.

Cheese.	Scoring.	Flavor. (Max. 40.)	Closeness. (Max 15.)	Even color. (Max 15.)	Texture. (Max. 20.)	Total. (Max. 100.)
April :		Av.	Av.	Av.	Av.	Av.
A.	{ 1st scores .. All " ..	37.0 35.7	15.0 14.7	15.0 14.2	18.0 17.6	95.0 92.3
B.	{ 1st scores .. All " ..	37.0 35.5	14.5 14.6	15.0 14.1	18.0 17.4	94.5 91.5
C.	{ 1st scores .. All " ..	35.5 34.5	15.0 14.7	15.0 14.1	19.0 17.4	94.5 90.7
D.	{ 1st scores .. All " ..	39.0 35.8	15.0 14.3	15.0 14.1	19.0 17.7	98.0 91.9
E.	{ 1st scores .. All " ..	34.5 25.6	14.0 14.1	14.5 11.5	16.5 15.5	89.5 76.7
May :						
A.	{ 1st scores .. All " ..	37.3 36.1	15.0 14.7	14.8 14.1	18.3 17.9	95.4 92.9
B.	{ 1st scores .. All " ..	37.5 35.9	14.5 14.4	14.3 13.7	18.3 17.8	94.6 91.8
C.	{ 1st scores .. All " ..	37.5 35.4	14.8 14.5	14.8 13.8	18.5 17.5	95.6 91.2
D.	{ 1st scores .. All " ..	37.8 35.8	14.8 14.4	14.5 13.8	18.0 16.9	95.1 90.9
E.	{ 1st scores .. All " ..	32.3 33.9	13.5 13.9	14.0 13.9	16.3 16.2	89.1 87.9
June :						
A.	{ 1st scores .. All " ..	33.5 33.5	14.8 14.8	14.5 14.5	17.5 17.4	90.3 90.2
B.	{ 1st scores .. All " ..	33.3 34.3	14.1 14.5	14.3 14.1	16.8 17.1	88.5 90.0
C.	{ 1st scores .. All " ..	33.3 34.0	13.9 14.0	14.3 14.0	16.8 17.3	88.3 89.3
D.	{ 1st scores .. All " ..	33.5 34.1	13.3 13.8	13.8 13.9	16.8 17.1	87.4 88.9
E.	{ 1st scores .. All " ..	33.0 31.6	14.3 14.1	14.4 14.0	15.5 15.2	87.2 84.9
July :						
A.	{ 1st scores .. All " ..	35.2 35.5	14.5 14.4	14.5 14.6	17.4 17.5	91.6 92.0
B.	{ 1st scores .. All " ..	35.6 35.8	14.2 14.3	14.2 14.4	16.8 17.1	90.8 91.6
C.	{ 1st scores .. All " ..	35.7 35.9	14.1 14.1	14.1 14.3	17.2 17.2	91.1 91.5

SCORING OF THE CHEESE.—*Concluded.*

Cheese.	Scoring.	Flavor. (Max. 40.)	Closeness. (Max. 15.)	Even color. (Max. 15.)	Texture. (Max. 20.)	Total. (Max. 100.)
July :		Av.	Av.	Av.	Av.	Av.
D. {	1st scores ..	35.9	13.9	14.0	17.1	90.9
	All " ..	36.0	14.1	14.2	17.1	91.4
E. {	1st scores ..	33.7	13.6	14.0	15.7	87.0
	All " ..	33.4	13.7	13.9	15.9	86.9
August :						
A. {	1st scores ..	36.3	14.3	15.0	17.7	93.3
	All " ..	36.2	14.4	15.0	18.2	93.8
B. {	1st scores ..	36.3	13.3	15.0	17.7	92.3
	All " ..	36.6	13.8	15.0	18.4	93.8
C. {	1st scores ..	35.0	14.3	14.6	17.7	91.6
	All " ..	35.2	14.2	14.6	17.8	91.8
D. {	1st scores ..	35.7	13.7	14.6	17.3	91.3
	All " ..	35.8	14.0	14.6	17.6	92.0
E. {	1st scores ..	34.7	14.0	14.3	17.0	90.0
	All " ..	35.0	14.0	14.3	17.3	90.6
September :						
A.	1st scores ..	36.5	14.3	14.8	18.8	94.4
B.	" ..	36.2	14.6	14.6	18.7	94.1
C.	" ..	35.7	14.5	14.6	18.2	93.0
D.	" ..	35.8	14.0	14.5	18.0	92.3
E.	" ..	32.2	13.6	13.8	16.8	86.4
October :						
A.	1st scores ..	37.7	13.6	14.0	19.0	94.3
B.	" ..	35.3	13.3	13.3	18.1	90.0
C.	" ..	36.3	13.0	13.3	18.0	90.6
E.	" ..	28.3	13.7	11.3	17.0	80.3
November :						
A.	1st scores ..	36.5	14.5	14.0	18.5	93.5
B.	" ..	36.0	13.0	14.0	18.0	91.0
C.	" ..	36.5	13.0	13.0	18.0	90.5
E.	" ..	26.5	14.0	12.5	16.5	79.5
Average for season :						
A. {	1st scores ..	36.0	14.5	14.5	18.0	93.0
	All " ..	35.7	14.5	14.3	17.9	92.4
B. {	1st scores ..	35.7	14.1	14.3	17.6	91.9
	All " ..	35.6	14.3	14.1	17.6	91.6
C. {	1st scores ..	35.6	14.1	14.2	17.7	91.6
	All " ..	35.2	14.2	14.0	17.5	90.9
D. {	1st scores ..	35.8	13.9	14.2	17.4	91.3
	All " ..	35.4	14.1	14.0	17.2	90.7
E. {	1st scores ..	32.7	13.7	13.7	16.3	86.4
	All " ..	31.7	13.9	13.4	16.0	85.0

The cheese made during April, May, June, July, and August were scored several times during the year, some as late as January 18th, 1902. All the cheese made during September, October and November were scored but once, when three to four months old. The first scoring of the cold-storage cheese was usually made when they were three to four months old. The cheese made from April to August and ripened in the ordinary room were scored the first time when six weeks to two months old. They were scored at intervals of about one month after the first scoring until it was considered there would be no advantage in keeping them for a longer time.

CHEESE SENT TO MONTREAL.

Four cheese, made on July 8th, were sent to Montreal to be scored by cheese merchants in that city. Mr. R. M. Ballantyne, of the firm of Lovell & Christmas, very kindly took charge of the cheese, which were scored by leading men in the trade. The scoring was done on November 11th, when the cheese was four months old. When their scores were all averaged, the cheese put directly into cold-storage from the hoops scored an average of 92.1 points. The cheese put into cold-storage at the end of a week scored 89.8 points; the one put into cold-storage at the end of two weeks scored 84.8; and the one placed in storage after being in an ordinary ripening-room for three weeks scored an average of 80 points. The scorers were not told which cheese were put directly into cold-storage until after their score-cards were marked.

Mr. Ballantyne reported as follows: "They (the merchants) universally expressed surprise at the condition of the cheese that were put into cold-storage at the earliest period, as they expected to find the cheese still in a curdy condition, and probably with a bitter flavor. It would appear from these as if cheese held in cold-storage from the time of manufacture would give better satisfaction than if held for some time in the ordinary curing-room before being put into cold-storage."

Writing further on the 15th November, Mr. Ballantyne says, "If this experiment is borne out by other experiments, it would appear as if the best way to handle hot weather cheese would be to ship them directly after making to the cold-storage, and this would certainly mean a great revolution in the trade."

WHITE SPECKS IN THE CHEESE.

At the time of filling the ice-house of the refrigerator in which the cheese were stored, the temperature went as low as 10° and the cheese were frozen. This caused the cheese then on hand to become crumbly in nature, and some time after white specks, or what looked like curdy matter, appeared in the cheese. The cheese on hand at the time of writing (April 20th, 1902,) still have the white specks. Just when the specks

appeared we are unable to say, but they were not noticed in the cheese until after they were frozen. The specks were found in cheese which had been moved from the cold-storage to a warmer room, and also in the cheese which had not been moved from cold-storage.

POSSIBILITY OF INCREASED YIELD OF CHEESE.

In addition to a saving of at least 2 per cent. in shrinkage, the adoption of a lower temperature for ripening cheese points to the possibility of obtaining a greater yield of cheese by cooking at a lower temperature and stirring the curd less. If such cheese are ripened in an ordinary room, they are likely to develop too much acid and be "short" and "mealy" in texture. By ripening them at 40° to 50° no such mealiness is observed, and the extra yield of cheese is equal to about one and one-quarter pounds per 1,000 lbs. of milk. If further experiments confirm these results, it means a large increase in the returns to cheese factory patrons.

CONCLUSIONS.

1. An ice cold-storage chamber, with circulation of air, may be maintained at a temperature of about 40° without moving the ice, if the building is well insulated.

2. The high percentage of moisture, 91.6 per cent., in the cold-storage made the conditions favorable for the growth of mould; yet the mould was no worse on the cheese in the refrigerator than on the cheese in the ordinary ripening-room. In both places the mould was kept in check by the use of a solution of formalin sprayed on the cheese with a hand spray-pump.

3. The acidity of the whey increased up to the time of salting the curd, when it decreased, and then increased again.

4. The saving of loss in weight by ripening at an average temperature of 37.8° for the season was over 2 per cent on cheese weighing about 30 pounds each. This is a very important item in a large factory, and would alone pay the cost of cold-storage for cheese in hot weather.

5. The quality of the cheese was in the order of placing in the cold-storage as regards time—that put in directly from the hoops standing first. *Uniformity* of quality in all the cheese placed in cold-storage was the chief point noticed.

6. An increased yield of cheese equal to at least one pound of cheese per 1,000 pounds of milk may be looked for as a result of modifying the method of manufacture and ripening at a lower temperature than has been commonly supposed necessary.

7. It has been claimed that cheese kept in cold-storage for any length of time will spoil quickly when exposed to an ordinary temperature. Such results were not observed in the experiments conducted, nor are

they likely to occur when the cheese have been ripened for the whole period at a moderately low temperature. Further experiments are being made to settle this point.

8. A cheese put directly from the hoop into a dry box and placed in cold-storage, without any turning, ripened satisfactorily. The chief defect was in the large amount of mould on the cheese. A cheese put into a box after ripening in the ordinary room for a week gave similar results. Two cheese made from the same vat of milk as the cheese put into the cheese-boxes, were placed on a shelf in the cold-storage, and the quality was similar to that put directly into a box from the hoop, and to that put into a box at the end of one week. The cheese-boxes should be well seasoned, if the cheese are not to be removed from the boxes. We would also advise spraying the inside of box, and soaking the scale-boards with formalin, to prevent mould.

9 Undesirable bacteria such as are found in cheese seem unable to grow at a temperature of 38° F., and consequently bad flavors in cheese, caused by bacteria, do not increase in cold-storage.

10. The long life of the lactic acid bacteria in cheese seem to have an important bearing on the question of ripening, checking the development of bacteria which produce bad or undesirable flavors.

11. The temperature at which cheese will cure best is not yet settled. There are involved in the question many points which require further investigation.

ONTARIO AGRICULTURAL COLLEGE

BULLETIN 122

SPRAY CALENDAR.

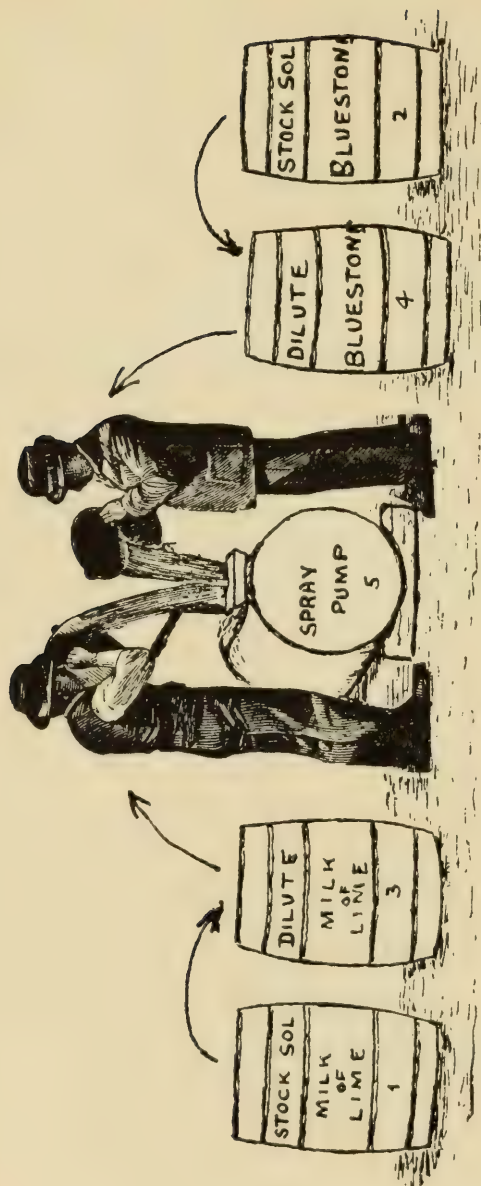
DIRECTIONS FOR TREATMENT OF INSECT
PESTS AND PLANT DISEASES.

BY

WM. LOCHHEAD, PROFESSOR OF BIOLOGY AND GEOLOGY,
ONTARIO AGRICULTURAL COLLEGE, GUELPH.

1. Thorough, intelligent spraying pays.
 2. Spraying is an insurance.
 3. Clean up refuse, gather up fallen leaves and fruit
in fall, and burn them.
 4. Protect birds and beneficial insects.
-

PUBLISHED BY
THE ONTARIO DEPARTMENT OF AGRICULTURE, TORONTO.
TORONTO, ONT., JUNE, 1902.



Proper method of preparing Bordeaux mixture. The stock solutions are made up and kept in barrels 1 and 2 ; these are diluted in barrels 3 and 4, and finally mixed in the spray pump, barrel 5.

SPRAY CALENDAR

DIRECTIONS FOR TREATMENT OF INSECT PESTS AND
PLANT DISEASES.

BY PROF. WM. LOCHHEAD.

FORMULÆ.

1. BORDEAUX MIXTURE (For Fungous Diseases).

Copper Sulphate (Bluestone).....	4 pounds.
Lime (fresh).....	"
Water.....	40 gallons.

In making this mixture, observe the following precautions and directions:

1. *Use nothing but fresh quick-lime.* The lime should be slowly slacked by the gradual addition of water.

For convenience stock solutions of milk of lime and bluestone should be prepared and kept in different barrels in readiness for spraying operations. In barrel No. 1, 25 pounds of fresh lime are gradually slaked, and barrel made up to 25 gallons of water; in barrel No. 2, 25 lbs. of copper sulphate, or bluestone, are dissolved in 25 gallons of water. For rapid dissolving use warm water. These are the stock solutions. Each gallon of milk of lime contains one pound of lime, and each gallon of bluestone solution contains one pound of bluestone. When we wish to make up a barrel of Bordeaux mixture, we take out 4 gallons of milk of lime, and 4 gallons of bluestone solution, and either dilute each in separate barrels in 20 gallons of water before mixing in the barrel attached to the spray-pump, or else pour each separately into the barrel in which are already 32 gallons of water. The first method is the preferable one.

2. *Never mix the concentrated stock solutions together.* If the milk of lime and bluestone are mixed in the concentrated form, just as they are taken from the stock solution, a precipitate of a flakey nature will soon settle out, and either fall to the bottom or clog the nozzle.

3. *Test the Bordeaux to find out whether sufficient milk of lime has been added.* This is most easily done by means of the ferrocyanide test. A saturated solution of this substance can be purchased at any druggist's for a few cents. In testing, place some of the Bordeaux, which has been thoroughly stirred, into a saucer, and add a few drops of the ferrocyanide. If sufficient lime has been used, no discoloration will appear, but if insufficient, a deep dark brown color will be produced.

4. *Always strain the milk of lime to prevent gritty particles from clogging the nozzles.*

5. *Use a fine nozzle ; do not soak or drench the tree.*

6. *The stock solutions will keep, but the Bordeaux mixture becomes useless after standing for a day or two.*

2. THE COMBINATION BORDEAUX AND PARIS GREEN MIXTURE.

(For Fungous Diseases and Leaf-eating Insects).

This mixture is prepared like the Bordeaux, but 4 ounces of Paris green are added and thoroughly stirred before spraying.

Copper sulphate (Bluestone).....	4 lbs.
Quick lime (fresh).....	4 lbs.
Paris green.....	4 oz.
Water (1 barrel).....	40 gals.

In small quantities it may be made as follows :

Bluestone.....	4 level tablespoonfuls.
Quick lime.....	4 “
Paris green.....	1 “
Water.....	1 pail (2 gals.)

3. COPPER SULPHATE (Bluestone or Blue Vitriol).

(For destroying Mustard or Charlock or Herrick in grain fields.)

Copper sulphate	9 pounds.
Water (1 barrel)	45 gallons.

This quantity is sufficient for an acre.

4. AMMONIACAL COPPER CARBONATE SOLUTION.

Copper carbonate	1 ounce.
Strong ammonia sufficient to dissolve the copper carbonate, usually more than	$\frac{1}{2}$ pint.
Water	10 gallons.

This solution is not much used, and is recommended only in cases where the fruit is so far advanced that it would be disfigured by using the Bordeaux mixture.

5. POTASSIUM SULPHIDE (Liver of Sulphur).

(Used to control Gooseberry Mildew.)

Dissolve 4 oz. in 8 gallons of water.

6. PARIS GREEN MIXTURE. (Liquid.) (For Leaf-eating Insects.)

Paris green	1 pound.
Water.....	150 gallons.
Lime	2 lb. freshly slacked.

Or,

Paris green	1 teaspoonful (level).
Water	1 pail (2 gallons).
Quick lime	1 teaspoonful (level).

Paris Green Mixture. (Dry.)

Paris green.....	1 pound.
Flour or dust	100 pounds.

7. POISON BAIT. (For Cutworms, Wireworms and Grasshoppers in gardens and cornfields.)

Wheat bran	50 pounds.
Molasses (any kind)	2 quarts.
Paris green (good grade) ..	1 pound.
Water.....	(Enough to make a thick mash.)

Handfuls of the bait are scattered about the garden at the base of the plants and among the corn rows in the evening.

8. HELLEBORE.

White hellebore (fresh)	1 ounce.
Water	2 gallons.

9. PYRETHRUM, or Insect Powder.

Pyrethrum powder (fresh)	1 ounce.
Water	3 gallons.

Or,

Pyrethrum Powder.....	1 ounce.
Flour (cheap).....	5 ounces.

Mix thoroughly, allow to stand over night in a closed box, then dust on plants through cheese-cloth.—Recommended for green cabbage worm.

10. KEROSENE EMULSION (for Bark-lice and Plant Lice).

Hard soap.....	$\frac{1}{2}$ pound, or soft soap	1 quart.
Boiling water (soft)		1 gallon.
Coal oil.....		2 gallons.

After dissolving the soap in the water, add the coal oil and stir well for 5 to 10 minutes. When properly mixed, it will adhere to glass without oiliness. A syringe or pump will aid much in this work. In using, dilute with from 9 to 15 parts of water. Kerosene emulsion may be prepared with sour milk (1 gallon), and coal oil (2 gallons), no soap being required. This will not keep long.

11. TOBACCO DECOCTION.

Refuse tobacco.....	2 pounds.
Water.....	5 gallons.

Boil the mixture for 30 minutes or more, until a dark brown tea-colored solution is obtained. Keep it covered until cool. It may then be used undiluted for spraying infested plants.

12. WHALE OIL SOAP.

For Plant Lice. 1 lb. in 7 gallons hot water.

For San José Scale in winter. 2 lbs. in 1 gal. hot water applied as the buds are swelling.

13. SOAP SOLUTION.

For Plant Lice on house plants a 5c cake of soap in 4 gals. water.

14. CRUDE PETROLEUM. (For San José Scale in early spring.)

A 20 per cent. mechanical emulsion applied by a combination emulsion pump to infested trees just before the buds start. (To be done by an experienced person.)

14 (a). CRUDE PETROLEUM—WHALE OIL SOAP EMULSION.

(Recommended for San José Scale, and other hibernating insects.)

Crude petroleum.....	2 gallons.
Whale oil soap.....	5 lbs. dissolved in 1½ gallons of boiling water.

Churn thoroughly for 5 minutes or more, and add water to make 10 gallons.

15. WASH FOR BORERS.

First, add soft soap to a saturated solution of washing soda to make a thick paint, then add 1 pint crude carbolic acid, and ½ pound Paris green to 10 gals. of wash.

To be applied to the trunks of apple and maple shade trees in early June.

16. LIME WASH.

(For Oyster-shell Bark Lice, etc.)

Slake 1½ lbs. fresh lime in 1 gallon of water. Strain the wash before spraying. To be applied during winter to trees infested with oyster-shell bark lice.

17. FORMALIN.

(a) *For Potato Scab.* 8 oz. or ½ pint in 15 gals. water. Soak seed potatoes in this solution for two hours.

(b) *For Smut in Oats and Wheat.* 8 oz. or ½ pint in 5 gals. water. Sprinkle thoroughly the seed with this solution.

18. CARBON BISULPHIDE.

For weevils in peas and grain.

1 lb. or 1 pint for every 100 bushels of grain, or 1,000 cubic feet of space. Liquid placed in shallow dishes on top of grain or peas.

TREATMENT.

APPLE AND PEAR.

A. Against Leaf-eating Insects and Fungous Diseases.

Treatment.	When to spray.	Insect pests and diseases controlled.
1. Paris green in water. (Formula 6.) (Important.)	Just as leaf-buds are expanding.	Bud-moth, case-bearers.
2. Bordeaux mixture and Paris green. (Formula 2.)	About a week later . . .	Bud-moth, case-bearers, canker-worms, tent-caterpillars. Scab, leaf-spot and mildew.
3. Bordeaux and Paris green. (Formula 2.) (Important.)	Just before blossoms open.	Canker-worms, tent-caterpillars, etc. Scab and leaf-spot, etc.
4. Bordeaux and Paris green. (Formula 2.) (Important.)	Just after blossoms fall.	Codling-moth, canker-worms, tent-caterpillars, pear slug. Scab and leaf-spot.
5. Bordeaux and Paris green. (Formula 2.)	Ten days or two weeks later.	Codling-moth, Palmer worm, apple <i>Bucculatrix</i> . Scab and leaf-spot, etc.

Codling-moths cannot always be controlled by spraying, especially in the south-western section of Ontario, where a second brood appears later in the season.

In addition to spraying, in this district, use bandages around the trees. Make them from four to six inches wide, three or four inches thick, of any kind of cloth. Old bags, sacks, carpets, coarse material of any kind will do. Bands of straw and tow have been used with some success. During the first week in June bind one around each tree three or four feet from the ground; secure it either with cord or small nails; take it off every twelve days, and carefully examine for codling cocoons. These may be readily destroyed by crushing. Replace the bands as before.

Tent-caterpillars are controlled by burning the webs or nests in May; by collecting and destroying the clusters of eggs in fall and winter; by banding the trees; and by spraying the young caterpillars with Paris green.

Canker-worms may be largely controlled by banding the trees in autumn and early spring; and by spraying with Paris green when the worms appear.

B. Against Sucking Insects, such as Plant-lice and Scale Insects, and against Pear Leaf Blister-mites.

Treatment.	When to spray.	Insects controlled.
1. Kerosene emulsion (Formula 10), (1 part in 10 parts water).	Before buds start in spring.	Pear-leaf blister-mite.
2. Kerosene emulsion solution (1 part emulsion to 10 parts water). Or whale-oil soap solution (Formula 12), (1 lb. to 7 gals. water).	As leaves are unfolding.	Pear psylla and aphids.
3. Kerosene emulsion (Formula 10), whale-oil soap as before.	Ten days later	Psylla and aphids.
4. Kerosene emulsion (Formula 10), or whale-oil soap as before. Or lime wash (No. 16).	About end of May or first of June. During winter.	Oyster-shell bark-lice.

C. Treatment for destroying borers:

- (a) Dig out the borers whenever possible.
(b) Apply the soap-soda wash (Formula 15) in early June.

PLUM AND CHERRY.

A. Against Curculio, Brown Rot, Shot-hole Fungus, and Leaf-eating Insects.

Treatment.	When to spray.	Insects and diseases controlled.
1. Bordeaux and Paris green. (Formula 2.)	When leaf-buds are opening.	Brown rot, shot-hole fungus.
2. Bordeaux and Paris green. (Formula 2.)	When fruit is formed. .	Curculio, green fruit worms, brown rot, etc.
3. Bordeaux and Paris green. (Formula 2.)	Two weeks later	Brown rot, curculio, etc.
4. Ammonia-copper carbonate solution. (Formula 4.)	When fruit is large. . .	Brown rot, etc.

The *Curculios* are most readily controlled by jarring the trees in early morning, and collecting them on a sheet spread under the tree. The jarring should be begun when the fruit has set, and continued for three weeks. Thrice a week is often enough to jar.

B. Against Plant-lice and Scale Insects.

Treatment.	When to spray.	Insects controlled.
1. Kerosene emulsion (Formula 10), (1 part to 4 parts water.) Or whale-oil soap, (2 lbs. to 1 gal. hot water.) Or petroleum soap emulsion. (Formula 14a.)	In winter or early spring.	Plum scale, San José Scale, etc.
2. Kerosene emulsion (Formula 10), (1 part to 10 parts water.) Or whale-oil soap solution. (Formula 12), 1 lb. to 7 gals. water.) Or tobacco solution (Formula 11.)	As soon as lice appear on young leaves.	Plant-lice.

PEACH.

A. Against Peach-leaf Curl, Brown Rot, Curculio, Bud-moth.

Treatment.	When to spray.	Insects and diseases controlled.
1. Bordeaux and Paris green. (Formula 2.)	Before flower buds open	Bud-moth and peach leaf curl, brown rot.
2. Bordeaux and Paris green. (Formula 2.)	After blossoms fall . . .	Peach-leaf curl, brown rot, bud-moth and curculio.
3. Bordeaux and Paris green. (Formula 2.)	Two weeks later	Brown rot, etc.
4. Ammonia-coppercarbonate. (Formula 4.)	When fruit is well-formed.	Brown rot, etc.

B. Against Aphis, and Scale Insects.

1. Kerosene emulsion (Formula 10), (1 part in 10 parts) Or whale-oil soap (Formula 12), (1 lb. in 7 gals. water.	Whenever young lice appear.	Aphis.
Whale-oil soap, (2 lbs. in 1 gal. hot water. Or crude petroleum. 25 per cent. me- chanical emulsion. (Slightly dangerous.)	In early spring before buds open.	San José scale.

C. Against Peach Tree Borer.

1. Prof. Slingerland recommends *gas tar* as a trunk wash. A trial experiment should be made first on a few trees to find out if it injures the trees, for gas tar varies in composition.

2. Dig out or probe the borers every fall and spring ; and mound up a new base with earth for six inches ; remove and examine in September.

3. Apply Formula in early June.

GRAPE.

A. Against Black Rot, Mildews and Leaf-eating Insects.

Treatment.	When to spray.	Insects and fungi controlled.
1. Bordeaux and Paris green. (Formula 2.) (Important.)	As buds begin to swell.	Flea-beetle, black rot, mildews.
2. Bordeaux and Paris green. (Formula 2.)	Ten days or two weeks later, before blossoms open.	Black rot, mildews and flea- beetles.
3. Bordeaux and Paris green. (Formula 2.)	Just after blossoming.	Black rot and mildews.
4. Bordeaux and Paris green. (Formula 2.)	Two weeks later.	Flea beetle and black rot.
5. Ammonia-copper car- bonate. (Formula 4.)	When fruit is well formed.	Black rot and mildews.

B. Against Grape Thrip.

1. Kerosene emulsion, 1 part in 9 parts water.	Soon after leaves are formed.	Thrip or leaf-hopper.
--	----------------------------------	-----------------------

CUCUMBER AND SQUASH.

For the Squash Bug. Kill the early bugs, and the yellowish eggs on the underside of the leaves; kill the bugs every morning which collect under chips and boards placed near the vines.

For the Striped Cucumber-beetle. Keep vines well covered with Bordeaux mixture; cleanliness in garden in fall; protect young vines with muslin, or cheesecloth netting; insect powder and flour as for cabbage worm; tobacco-water and soft soap mixture sprinkled on vines, followed by a dusting of lime.

ASPARAGUS.

For Beetles. Spray plants after cutting season with Paris green; regular cutting of all shoots.

For Rust. Cut and burn all plants in fall.

CABBAGE.

For Cabbage Worms and Lice. Pyrethrum applied in solution (1 ounce to 3 gallons of water) or dusted on (1 part pyrethrum to 5 parts flour).

For Cabbage Root-Maggots. No thoroughly reliable remedy is known, but good results have been obtained by using Goff's *Tarred-Paper Cards*. These are pieces of tarred building paper, 3 inches in diameter. In the centre is a hole through which the root of the young cabbage is placed on transplanting. Card lies flat on ground.

STRAWBERRY. The *Rust* or *Leaf-blight*.

Bordeaux mixture, when it can be applied without disfiguring the fruit, will control this disease. Apply at intervals of two or three weeks on new beds after they begin to make runners.

TOMATO. *Rot* and *Blight*.

Spray with Bordeaux mixture, as soon as rot or blight appears, three times, if necessary, at intervals of 10 to 15 days.

POTATO. *Scab*, *Blight*, and *Beetles*.

For the Scab: Soak the "seed" potatoes or tubers for two hours in a solution of formalin (8 ozs. in 15 gals. of water)

For Blight and Beetles. First spraying: Paris green as soon as the beetles appear (one pound to 100 gallons of water).

Second spraying: Bordeaux mixture and Paris green when plants are six inches high.

Third and fourth sprayings: Bordeaux mixture at intervals of 10 to 15 days, if necessary.

Spraying with Bordeaux mixture will prevent the blighting of the plants and the rotting of the tubers.

RASPBERRY. *Anthracnose, Leaf-blight and Saw-fly Larvæ.*

First: Bordeaux mixture and Paris green just before growth begins.

Second: Bordeaux mixture and Paris green about when first blossoms open.

Third spraying: Bordeaux mixture when the fruit is gathered.

CURRANT AND GOOSEBERRY.

For Worms and Mildew. First spraying: Potassium sulphide or Bordeaux mixture and Paris green before the buds expand.

Second spraying: The same 10 to 15 days later.

For worms alone, hellebore or Paris green will be effective.

For Currant Plant Lice. Spray with kerosene emulsion or whale-oil soap solutions as soon as lice appear; or dust carefully with fine wood ashes.

CELERY. *Leaf-blight.*

First spraying: Bordeaux mixture (Formula 1) while in the seed bed.

Second spraying: Bordeaux mixture a week after transplanting.

PEAS. *Pea-weevil or Pea-"bug."*

Fumigate the peas as soon as threshed in tight bins, boxes or oil barrels, by placing carbon bisulphide in shallow pans on top of the peas, and covering the whole tightly for 36 hours. Use 1 lb. for 100 bushels; 1 oz. for 100 lbs. of peas; and a tablespoonful to every cubic foot. The same treatment may be used to kill weevils in grain and in meal. As this gas is explosive great care should be taken not to bring a light near it until it has been ventilated.

MISCELLANEOUS.

COW HORN-FLY. Apply with a brush on the parts most usually attacked a mixture of one quart of seal or fish-oil and one tablespoonful of crude carbolic acid.

MUSTARD. Spray just before the plants come into bloom, on a calm day. Use formula 3, and an ordinary barrel spray pump. A barrel of solution is enough for an acre.

BUFFALO CARPET BEETLE AND BLACK CARPET BEETLE. Take up infested carpets and spray with benzine: fill cracks in floor with putty or plaster paris; lay pieces of red flannel in closets as traps, which should be examined every week.

RED ANTS. Attract to a sponge filled with sugared water, and kill the collected ants by dropping them into boiling water. Repeat.

ROSE SLUGS. Apply hellebore before buds open, and at intervals of a week or ten days.

THRIP, OR LEAF-HOPPER, ON ROSE OR VIRGINIA CREEPER. Use tobacco solution; whale oil soap solution (1 teaspoonful in 2 quarts of water).

RED SPIDER. Syringe or spray with cold water, or tobacco water.

Ontario Agricultural College and Experimental Farm.

COLD STORAGE OF PEARS AND APPLES.

BY J. B. REYNOLDS, B.A., AND H. L. HUTT, B.S.A., GUELPH.

In the autumn of 1901, a series of experiments was conducted by the Department of Physics on the keeping of fruit in cold storage. As a beginning, it was thought wise to confine the experiments within narrow limits. Among many conditions the effects of which on the keeping of fruit are still unknown, three conditions were chosen for experimenting: (a) different temperatures; (b) different sizes of fruit; (c) different styles of packing.

One variety of pears, the Duchess, and one of apples, the Fameuse or Snow, were used in the experiment. The pears were supplied by Mr. A. W. Peart, of Burlington, and the apples by Mr. W. H. Dempsey, of Trenton. The fruit was packed in the orchard according to directions from this Department, and then shipped to cold storage warehouses in Toronto and in St. Catharines. Only first class specimens were packed.

The pears arrived at the cold storage warehouse about Oct. 1st, and the apples about Nov. 18th. Owing to some blunder at the Toronto warehouse, the section of pears that was being held at the low temperature was shipped out before being examined. For the pears, therefore, we have only one temperature to report upon.

THE EXPERIMENT WITH PEARS.

The plan in detail was as follows: The fruit was packed in two similar sections, one section to be held at a temperature of 31° , and the other at a temperature of 38° . Each section was redivided into two subsections identical in style of packing, the one containing large pears, the other medium-sized pears. In each of these subsections there were five boxes of pears, packed as follows:

- A. With pears only, no packing or wrapping.
- B. With excelsior (a sort of shredded wood) at bottom and top of pears in the box.
- C. With pears wrapped singly in tissue paper, and packed in layers, and excelsior above and below and between the layers.
- D. Same as C, with oil-paper instead of tissue paper.
- E. Same as D, with heavy wrapping paper between box and fruit, making the box air-tight.

The pears at St. Catharines, the section we are able to report upon, were held at 38°. Mr. Jos. Watson, the manager of the St. Catharines cold storage warehouse, very kindly agreed to examine the pears occasionally, and to ship them to this Department when he judged they were ready. The following table presents the results of detailed examination made at the College, with the dates :

Grade & style of packing.	Date examined.	Per cent. ripe.	Per cent. green.	Sound.	Bruised.	Decayed.
Large ; A ...	Nov. 23.....	89	11	27.5	67.5	5
Large ; B ...	" 23.....	88	12	24	66	10
Medium ; A..	Dec. 7.....	58	42	41.5	55.5	3
Medium ; B..	" 19.....	63	37	32.5	51	16.5
Large ; D ...	" 30.....	89	11	61.5	12	26.5
Medium ; D..	Jan. 8.....	100	..	69	4	27
Medium ; C..	" 8.....	100	..	50	15	35
Large ; C....	" 8.....	100	..	24	26.5	49.5
Medium ; E..	" 8.....	100	..	57.5	20	22.5
Large ; E....	" 8.....	100	..	58.5	14.5	27

There are three points to be observed in these results: First, influence of size of specimens on keeping quality; second, influence of style of packing on the proportion of sound fruit; third, marketable limit.

Making all due allowance for individual variations, we feel warranted in drawing the following conclusions:

1. *For long storage, the medium-sized pears give better results than the largest pears.* This is evidently a matter of maturity; the larger pears are on the whole riper than the smaller ones, if picked at the same time. It would, therefore, appear profitable with choice varieties to pick the larger pears, if intended for shipping or storing, two weeks earlier than the medium-sized ones.

2. *The style of packing is a most important consideration.* As an instance, let us consider, in the foregoing table of figures, the reports opposite *Large A*, and *Large D*, respectively. Packed bare in the box, these pears were examined on Nov. 23, and gave 89 per cent. ripe, and 27.5 per cent. sound, that is neither bruised nor decayed. With each pear wrapped in paper, and excelsior packed carefully between the layers, 89 per cent. were ripe on December 30, five weeks later than the date of equal maturity with the ordinary style of packing. 61.5 per cent. of the *D* style were sound at this date, as against 27.5 per cent. sound at the earlier date with the *A* style of packing. Again the *Medium A* were examined on December 7th, and 41.5 per cent. were sound. The *Medium D* were examined four weeks later, and 69 per cent. were sound.

The degree of ripeness was estimated partly by the feeling of the fruit, and partly by the color. It is not quite clear why the mere style

of packing should affect the ripening, except that the style of packing was more apt to give a steady temperature, and, besides, it excluded the light and thus probably influenced the coloring.

The style of packing had a most marked effect in preventing bruising, and hence decay. Fruit, such as apples and pears, packed loosely (without wrapping and filling material such as excelsior) is bound to settle in the barrel or the box, especially when handled frequently, as in shipping. Fruit thus settled is termed "slack" and this slackness gives opportunity for the individuals to be knocked against the sides of the box or against one another. The wrapping of each specimen in the box prevents mutual rubbing, and the excelsior filling, by its resilience or elasticity, prevents slackness and keeps the box full. The wrapping, by isolating the individuals, also prevents the spread of rot throughout the case.

3. *Under even the most favorable conditions, there is a limit beyond which it is unprofitable to hold pears.* That limit is reached when the fruit, or a considerable portion of it, is ripe. And it must be understood that cold storage is simply a means for retarding the ripening and decaying process. Cold storage postpones, but cannot avert, maturity and decay. Apparently, the limit for these Duchess pears was reached, at the storage temperature of 38° , at about Christmas for the medium-sized pears, and about two weeks earlier for the large-sized pears. The flavor of the sound well matured fruit, toward the end of December, was excellent, and it is evident from these experiments that good table pears might profitably be held in cold storage for the Christmas market.

At the conclusion of the experiment a quantity of the fruit was preserved in the College kitchen. These preserves are reported now (July 7th) as being of exceptionally fine quality, which is no doubt due, to some extent, to the fully-matured condition of the fruit when preserved.

To sum up, the best results were obtained with the medium-sized pears wrapped in oil-paper, packed with excelsior in a case lined with heavy wrapping paper, making it practically air-tight.

STORAGE OF SNOW APPLES.

The Snow apples were packed after the following styles :

- A. In an ordinary packing case, containing one-third of a barrel, without wrapping or filling ;
- B. In the case unwrapped, with excelsior top and bottom ;
- C. In the case, wrapped in tissue paper, with excelsior top and bottom and between the layers ;
- D. Wrapped in oil-paper, otherwise same as C ;
- E. In a barrel in the ordinary way.

This made four boxes and one barrel in the section ; and the section was duplicated, one being held at 38° and the other at 31° .

These apples reached the cold storage warehouse about Nov. 18th, and were shipped to Guelph about March 1st. The following table shows the results of the experiment :

Style of packing.	Temperature	No. of apples in case.	Per cent. sound.	Per cent. bruised.	Per cent. decayed.
A	38°	241	51	43	6
.....	31°	223	32.5	48.5	19
B	38°	182	39	36	25
.....	31°	202	53	34	13
C	38°	144	91	5	4
.....	31°	155	88	7	5
D	38°	144	80	11	9
.....	31°	145	86	8	6
E	38°	636	43	32	25
.....	31°	685	33	55	14

The same general conclusions are reached here as with the pears.

1. *As to the size of specimens:* Although in this regard no distinction was purposely made, yet it happens, as may be seen by glancing at the column under "Number of apples in each case," that there was a difference in average size. Opposite each style of packing, in every instance but one, it happens that the larger number of apples in each case (corresponding to a smaller average size) resulted in a smaller number of decayed specimens. In one instance, the C style, the proportion of decayed apples was practically the same in both cases. Apparently, the degree of maturity at the time of storage has more influence on the keeping quality than has a few degrees difference in temperature.

2. *As to the style of packing:* Apparently, there is not much to choose between the A, B, and E styles. At least, the figures are inconclusive. The C and D styles are by far the best. The averages of the unwrapped and the wrapped styles respectively are:—

	Per cent. sound.	Per cent. bruised.	Per cent. decayed.
Unwrapped.....	40	42	18
Wrapped and filled	86	8	6

The wrapping and filling has therefore the two-fold effect of preventing bruises, and preventing the spread of decay throughout the package. In the unwrapped fruit, three or four decayed specimens were frequently found in a group, showing that decay had spread from one apple to adjoining ones. In the other style of packing, the decayed specimens were isolated by the wrapping, and no rotting in groups occurred.

3. *As to the influence of temperature.* The individual results given in the large table above conflict somewhat, owing partly to the influence of size of specimens, and partly to accidental influences beyond our control.

The averages, however, are : 18 per cent. of decayed fruit in the cases kept at 38°, compared with only 13 per cent. at 31°. As the rate of decay is the only condition here affected by temperature, it follows that the lower temperature is more favorable for long storage of these apples.

4. *As to the marketable limit.* Under the most favorable conditions of temperature and style of packing, the apples were practically all sound on March 1. In appearance, they were as fresh as if just from the tree. In flavor, they had not deteriorated in the least. About the first week in March, some of the fruit was put into an ordinary cool cellar, where the temperature ranged between 35° and 40°. After about two weeks under these conditions, they began to lose flavor. Their marketable limit had been reached. It is quite probable that this limit might have been considerably extended, had the fruit been packed and stored immediately after it had been picked, instead of being held for a month or more in the fruit house, as it unavoidably was in this instance.

HANDLING OF FRUIT AFTER REMOVAL FROM COLD STORAGE.

It has been charged against cold storage that produce quickly deteriorates after being removed from cold storage conditions. That it usually does so, is quite natural. If the produce has been held for a considerable length of time in cold storage, the process of decay has been working, though very slowly. When the produce is removed from the low temperature into surroundings favorable to rapid decay, it is not to be expected that it will resist deterioration so well as if fresh.

Careful handling after removal from cold storage will lengthen the life of the fruit. In the apple experiment, two basketfuls of sound apples were selected from the same lot after examination. At the time of selection, the apples having been examined in a warm room, they were quite wet, owing to deposition of moisture from the warm air of the room upon the cold apples. They were "wets," as they are termed in the old country markets. One basketful of these wets was allowed to remain in the basket as they were. The other basketful was removed from the basket and spread out thinly over the table. The former lot remained wet for some time, the latter dried off quickly. Next day they were removed to the cellar and left there in the same way as described. After ten days they were again examined, with the following results :

	Sound.	Discolored.
First lot (left in basket)	70 per cent.	30 per cent. (12 p.c. rotten)
Second lot (spread out thinly) . . .	89 per cent.	11 per cent. (5 p.c. rotten)

The difference in these two lots was simply one of drying off quickly or remaining wet. It would have been better, of course, if they had not been allowed to become wet at all. To this end, the fruit should be warmed gradually, moisture not being allowed to form on its surface ; or the warm air should be kept from contact with the fruit, by a covering or an air-tight package, until the fruit has attained the temperature of the surrounding air.

COLD STORAGE FROM THE FRUITGROWER'S POINT OF VIEW.

The foregoing account of our fruit experiments shows that certain results may be reached by cold storage. It remains to be considered (1) whether or not such storage can be made commercially profitable, and (2) if so, how storage facilities may be obtained by the grower.

CONSIDERED COMMERCIALY. In considering the commercial side of the question, we must remember that the plan of storage recommended above as securing best results involves two items of additional expenditure: first, the extra cost of packing; and secondly, the cost of storage. The extra cost of packing, Mr. A. W. Peart, Burlington, Ont., who has packed a good deal of fruit in this way, estimates as follows:—

“Extra labor in wrapping, four cents per box.

“Wrapping paper and excelsior, three to four cents per box.

“Total extra cost, seven to eight cents per box.

“As against this, however, it must be borne in mind that four boxes of bare pears will make about five boxes of wrapped ones.”

There is also to be added on the credit side, the saving of fruit from bruising and decay by the superior method of packing; and this, for the fruitgrower who looks to the future, means, besides the actual saving of fruit, the possibility of establishing a reputation for furnishing an article of first-class quality.

As to the cost of storage, the wisdom or unwisdom of incurring the expense will depend entirely upon the state of the market when the fruit is harvested, the probable difference between present rates and rates a month or three or six months hence, or the difference between local prices and prices in the foreign markets (for storage implies storage in transit as well as in the warehouse). In fact, this being a commercial question, is solved as all commercial questions are, by taking the risk, and depending upon increase in prices to repay cost of holding and shipping. As to the probability of profit from such a venture we quote the following from the United States Year Book for 1900: “Most storage establishments store apples in carload lots at about forty cents per barrel for the season ending May 1st, and it is rarely the case that sound fruit does not advance more than that in price by March 1st, while a rise of \$1 or even \$1.50 per barrel is not infrequent.”

COLD STORAGE CONSIDERED MECHANICALLY. As to the question of securing cold storage accommodation, there is, first of all, the *cellar*, available to all. For late fall and winter storage a well-ventilated cellar will serve the purpose of the family in preserving apples and late pears. In this statement there is, of course, nothing new; but it is necessary to repeat at this juncture that there are three reasons for the spoiling of fruit in cellars: First, the fruit, all or part of it, may be of poor quality when stored. Then the handling, packing, or manner of storing the fruit may be careless. Finally, the storage room may be badly ventilated and uneven in temperature. The cellar should be well ventilated, with the window or windows open as much as possible, so long as the temperature

does not drop below freezing. If the windows are left open, the temperature of the cellar will require careful watching, and a thermometer suspended about the middle of the room is advisable. A proper average temperature for a mixture of fruit and vegetables is 36°F., and the temperature of the cellar should be kept at that point as steadily as possible. Of course, with early fruits that are stored during the warm weather of September and October this temperature cannot be reached, nor yet in the spring with late-keeping fruits. The cellar, however, even at these times, will likely be cooler and steadier in temperature than any place above ground, not artificially cooled; and, therefore, it is better to make the most of it. Fruit that is intended for long keeping *should be packed and stored immediately after picking*, and not left in heaps in the orchard or the shed.

A *small ice-storage* is another means for preserving fruit. This is superior to the cellar in warm weather, and, therefore, generally more suitable for this purpose. For private purposes, an ice-storage may be built for \$250 and upward, according to the size and the style of insulation. It includes a refrigerator, or storage room, and an ice-house attached, where the ice is stored in the winter and does its duty without being rehandled. The refrigerator is cooled after the most approved fashion by the circulation of air between that chamber and the ice-house. Plans for the building of such refrigerators may be had on application to the Ontario Department of Agriculture or to the writer of this bulletin. Some comments on refrigerators of this kind may be found in the Ontario Agricultural College Report for 1901.

While this kind of storage is generally satisfactory if properly constructed, it has limitations inseparable from refrigerators cooled by ice. The principal of these limitations is that of temperature. It is difficult to keep the temperature down to the lowest desirable limit in summer, and in winter there is danger of freezing. Especially is this the case while the ice is being put in, and afterwards.

The third method is the large co-operative storage, owned and operated by a company of fruit-growers, situated at a railway depot and in the midst of a fruit-growing district. This kind of storage accommodation has many advantages. The fruit stored here can be marketed promptly and without long hauls. A large company can afford to build a well-equipped plant, well insulated, and well provided with the best arrangements for refrigeration, and to employ a capable manager, to look after the fruit and to see that the temperature and humidity of the various rooms are of the proper degree. While a fairly satisfactory plant on a large scale can be refrigerated by the use of ice, the large plants of the future will be cooled by machinery. There is an account of such a plant in the last April number of the "Canadian Horticulturist."

A fourth means of storage is the large warehouse, where space may be rented. There are a few of these in Ontario now, there will be more when the demand increases. The rates at these are moderate, so moderate that it can rarely happen that the fruit-grower will not have a good

margin of profit after deducting the cost of storage from the advance in the price of fruit during the storage season. I have at hand a price-list from a large cold storage warehouse, giving storage rates as follows:

Barrel, 10 cents per month 25 cents per season ending May 1st.
Bushel box, 5 cents per month, 15 cents per season. Box containing one-quarter barrel, 4 cents per month, 12 cents per season.

SUMMARY.

1. Apples and pears keep best when wrapped singly in paper, and packed in a shallow box not larger than a bushel. They ship best when, in addition, they are packed in layers with excelsior between.

2. Apples keep better at a temperature of 31° than at a higher temperature. Our experiments do not show what is the best temperature for pears.

3. Cold storage cannot make bad fruit good; neither can it keep bad fruit from becoming worse. Only good specimens will keep for any length of time in cold storage, or will pay for storage.

4. For long storage, it pays to select the best fruit and to pack it in the best manner known. The extra labor and the cost of material are more than repaid in the greater quantity and better quality of fruit left at the end of the storage period.

5. With apples and pears at least, and, it seems likely, for most kinds of fruit, the fruit should be picked and stored in advance of dead ripeness. The maturing process goes on more slowly in cold storage than on the tree or bush.

6. With the two kinds of fruit tried, apples and pears, the medium sizes of fruit keep longer than the largest, all being perfect specimens and picked at the same time. It would, therefore, be an advantage, especially with pears and peaches, to pick the larger specimens first, and leave the smaller to mature later.

7. Fruit, on being removed from cold storage, should be allowed to warm gradually, and moisture should not be allowed to deposit upon it. But if the wetting cannot be prevented, then the fruit should be spread out and dried as quickly as possible.

8. With all kinds of fruit, there is a time limit beyond which it is unprofitable to hold the fruit in cold storage, or anywhere else. That limit, for sound fruit, is dead ripeness. Duchess pears can be kept profitably until late in December; Fameuse, or Snow, apples, until March or April. The time limit has to be determined for each kind of fruit.

9. In addition to proper conditions in the storage room, the most important points in the storage of fruit are the *selection* of sound fruit, *grading* into uniform sizes, one variety only in a case; and careful *packing*. Therefore, the results of these experiments can be made use of by the family, in preserving fresh fruit for their own use; by the fruit-grower, in securing better prices for good fruit later in the season, in the local markets; and by the shipper, in enabling him to take advantage of the higher prices offered in foreign markets.

5124
ONTARIO AGRICULTURAL COLLEGE

BULLETIN 124.

NATURE STUDY

OR

STORIES IN AGRICULTURE

BY

MEMBERS OF THE STAFF

OF

The Ontario Agricultural College, Guelph.

*PUBLISHED BY THE ONTARIO DEPARTMENT OF AGRICULTURE,
Toronto, December, 1902.*

PRINTED BY L. K. CAMERON,
Printer to the King's Most Excellent Majesty.

CONTENTS

	PAGE
Introduction	3
James Mills, M.A., LL.D., President.	
A Handful of Earth	5
J. B. Reynolds, B.A., Prof. of Physics.	
The Story of Plant Roots	10
Melville Cumming, B.A., B.S.A., Associate Prof. of Agriculture.	
The Story of a Grain of Wheat	16
C. A. Zavitz, B.S.A., Director of Field Experiments.	
The Story of a Loaf of Bread	20
Robert Harcourt, B.S.A., Prof. of Chemistry.	
The Story of the Yeast Plant	26
F. C. Harrison, B.S.A., D.P.H., Prof. of Bacteriology.	
The Story of a Pound of Butter	30
H. H. Dean, B.S.A., Prof. of Dairy Husbandry.	
The Story of the Cabbage Butterfly	37
W. Lochhead, B.A., M.S., Prof. of Biology.	
The Story of the Bees	43
H. R. Rowsome, Lecturer in Apiculture.	
The Story of the Birds	48
M. W. Doherty, B.S.A., M.A., Associate Prof. of Biology.	
The Story of an Apple	53
H. L. Hutt, B.S.A., Prof. of Horticulture.	
The Story of Sugar	58
W. P. Gamble, B.S.A., Associate Prof. of Chemistry.	
The Story of an Egg	65
W. R. Graham, B.S.A., Lecturer on Poultry.	
The Story of Wool	69
G. E. Day, B.S.A., Prof. of Agriculture.	
Tomboy—The Story of a Colt	72
J. Hugo Reed, V.S., Prof. of Veterinary Science.	

All of the illustrations in this Bulletin signed J. B. are from drawings made for the purpose by Mr. John Buchanan, B.S.A., a graduate of the Agricultural College. The two illustrations on pages 9 and 25 are from drawings loaned by *The Weekly Star*, Montreal.

NATURE STUDY.

JAMES MILLS, M.A., LL.D.

Most people look at many things which they do not see, and hear many sounds to which they pay little or no attention. There are, for instance, many intelligent Canadians who have been looking at ash and elm trees all their lives, and they could not describe the bark, leaves, or general appearance of these two kinds of trees, so as to distinguish one from the other. They have also, no doubt, noticed half a dozen or more

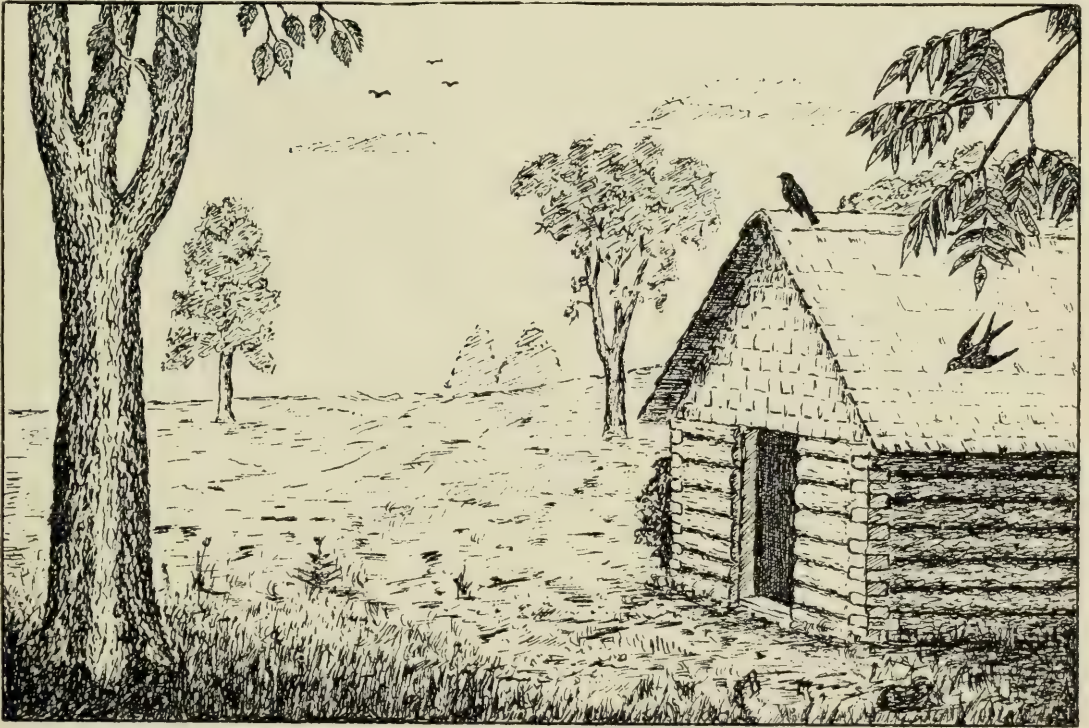


FIG. 1. What birds are these?
What trees are these?

species of birds in their fields or lawns from year to year, and have heard them sing very sweetly, and yet have little or no knowledge of most of them,—their color, markings, songs, or habits.

The aim of nature study is to interest men and women, and especially boys and girls, in the natural objects which they look at, handle, taste, or smell from day to day, in order that they may acquire the habit of observing closely, and so get all the pleasure possible out of their

surroundings in life, and find their daily duties less irksome, and gather information that will be helpful to them in overcoming difficulties and in working for a share of the necessities, comforts, and luxuries of life.

The materials for nature study are everywhere,—the soil, the plant, and the animal ; and the judicious study of soils and soil formation, or useful and troublesome plants, or noxious and beneficial insects—first, as objects of beauty or interest in themselves and afterwards as things which are useful or troublesome to man—opens up a field of unending pleasure and profit to the average boy or girl.

The eyes, ears, and other organs of sense in children are wide awake and keenly attentive ; and the one thing needed is nature-loving, well-trained, competent teachers in the Public Schools, to direct and develop the love for natural objects which is so strong from infancy to twelve or fourteen years of age.

One of the best aids—in fact the ever-necessary handmaid—of nature study is drawing. Nothing contributes more to exact and reliable information, say in the study of plants and insects, than an attempt to draw a representation of the object or organ under examination. All parts and the arrangement of parts, with every angle, curve, and peculiarity, must be noticed and represented in some way ; and I regret to say that there is nothing in which our Canadian teachers and schools are more deficient than in this important branch of elementary education. Boys from England are far more proficient in drawing than Canadian boys and girls ; and those who have given any attention to the subject, know what excellent work is being done under this head in some of the leading cities of the United States (say Boston, New York, and Philadelphia), where every teacher, in almost every division from the kindergarten up, teaches drawing. The children at school in these cities are taught to describe by some kind of diagram or drawing nearly everything they look at or read about ; and the results are very satisfactory,—far beyond what one would think possible in a Public School course.

Those who have had experience, almost without exception, say that nature study, properly pursued, does not interfere with ordinary school duties. On the contrary, it breaks the monotony of school routine and increases the interest in the regular school studies to such an extent that the most and best book-work is done where a little time is given every week to the examination and study of some portion of the great world of nature around us.

This Bulletin is, we think, the first formal attempt in the Province of Ontario to present items of information and simple, common-place incidents regarding natural objects, in the hope of interesting some of our young people, and inducing teachers to undertake such work in the Public and High Schools of the Province. These simple stories are, no doubt, very imperfect ; but they constitute a beginning,—the opening up of a very wide and interesting field for observation and study ; and with more time and a careful selection of writers according to their special tastes and aptitudes, we may be able to furnish something nearer what is required in this important department of educational work

A HANDFUL OF EARTH.

PROFESSOR. J. B. REYNOLDS.

“A handful of earth ! Dirt ! Surely we are not asked to listen to a story about anything so common as dirt ! Dirt sticks to our hands and faces, and we are made to wash it off. It clings to our shoes. It gets onto our clothes, it blows into the house, and makes the furniture dirty, and people have to be continually rubbing and brushing, sweeping, and dusting to get rid of it. We should be very glad never to hear of it again.”



Fig. 2. A handful of earth—in its place.

I fancy I hear many boys and girls saying this when they see the title of this story of mine. But stay ! I said *Earth*, and what you say is about *Dirt*. Earth is very good *in its place*, but *out of its place*, it is dirt. It is out of its place when it is on your hands or shoes or clothes. Then it annoys you and you call it bad names. There are other things besides earth that sometimes get out of place and are called bad names. I have heard it said that *boys and girls* are all very well in their place, which seems to hint that

they are sometimes out of their place. I have known boys, and girls too, make visits to a neighboring orchard. The owner of the orchard was a mean old fellow, and when he saw the children in his orchard he would say, “Plague on those youngsters : They’re at it again.” And he would send someone, or go himself, to drive them out, just as you would brush the dust off your hands. But the fathers and mothers of those same intruders thought they were pretty good children, and were proud of them. So with this handful of earth. In its place, that is, in the garden or field, it is of untold value.

Earth is so common and unlovely, while “birds and butterflies and flowers” are so bright and beautiful, that all our interest is naturally drawn to these. But we should know that although the soil has no life or beauty in itself, yet it *supports* life, and enables other things to be useful and beautiful.

THE SOIL AND THE ROCK.—Take from the field some fine dry earth. Place a good sized pinch of it on a piece of smooth white paper, and place under this a newspaper or a piece of thick cloth. Tip the whole so as to give it a little slope. Then tap this paper with the finger, and you will begin to see parts of the soil begin to draw away from the other parts. Keep at this, and you will find some of the soil rounding up in little heaps, while the rest scatters over the paper. Roll your pencil forwards and

backwards over this last, pressing slightly upon it, and tap again, until no more will round up. Then look closely at the little heaps and the scattered parts. The heaps first formed are made of soil fine as flour. The next lot of heaps have *little grains* like granulated sugar. The part scattered about is sand and lumps. The sand is mostly clear and white, some of the grains sparkling in the sun like diamonds. The lumps, perhaps, are made of smaller grains stuck together, and do not look clean-cut and white like the

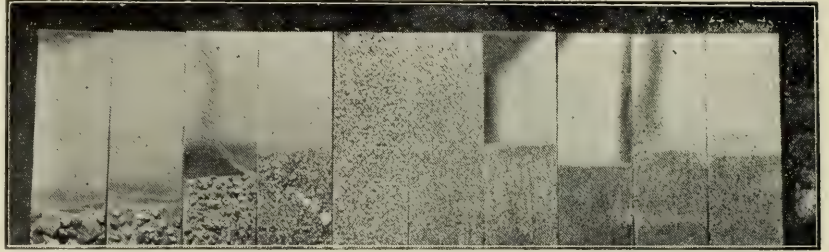


Fig. 3. A soil separated, showing rock grains of many sizes.

sand. Sand, as you well know, is nothing but small bits of rock. Now, if you hold the little heaps so that the sun shines upon them, you may see, if your eyes are sharp, very small rock-bits among these too. In fact, a large part of all soil is rock. When you come to know geology, you will learn how this rock became broken down into such small bits to make soil. But for the present we are interested in knowing that the soil contains rock-bits of many different sizes.



Fig. 4. Showing the parts that the trees have given to the soil.

THE SOIL AND THE TREE. "But," you say, "many soils are quite dark in color, while most of this sand is clear and white; There must be something else in soils besides sand grains, or it would not be so dark." Quite true; and now we shall see what this is.

Get from the woods, under last year's leaves, some black mold; and after it has become dried, treat it as you did the sample of earth. You will find much the same separation as before; but on looking closely at the heaps and scattered grains of the mold, you will find two important differences: First, the separate grains, big and little, instead of being white as the sand grains were, are all brown or black. Secondly, instead of looking like rock, these, especially the coarser ones, look like bits of wood.

Long years ago, before the white man came to Canada, even before the red man hunted over these hills and plains, the trees began to grow upon the soil. Year after year, as the trees grew bigger they drew water and food more and more, from the soil. The trees were wise, however, and knew that, although the rain that fell might keep up the supply of water that they needed, yet there was nothing to replace the food they took from the soil, unless they did it themselves. So they agreed to give back to the soil as much food as they took from it. Every year, the maples and the oaks and the beeches dropped their leaves

to the ground. Every tree in the forest now and then dropped twigs and broken branches. When a big tree died and decayed, it also fell to the ground, and lay stretched with its arms spreading wide. Slowly but surely all these things—leaves, twigs and trees,—rotted and passed back into the form of mother Earth. And thus the mold, which you find so common in forests, was made.

It is this *vegetable matter*, or humus, that makes soils dark. It is the most valuable and enriching part of the soil, and so nearly all the best soils are dark. The

virgin soil of Canada, that is, the soil before it was cultivated or cropped, wore a thick coat of rich brown mold over the sand-grains below. Through many years of plowing and cultivating, these two parts—the humus and the rock—have become mixed together, just as you found in the earth you examined. Wood and leaves are not the only sources of humus. Straw, roots, grass, and clover, if left on the land, will finally become humus.

THE SOIL AND THE RAIN. It was a dry hot summer day. In the fields, the corn and clover leaves hung limp and lifeless. In the gardens, the flowers bent their heads, and had hardly strength enough to put forth their buds. There had been no rain for many days, and the plants had had very little to drink but the dew that gathered on their leaves at night. So they were all very thirsty.

That night the rain fell in a long, heavy shower, upon the fields and gardens. On the steep hillsides it fell, and ran down in torrents to the

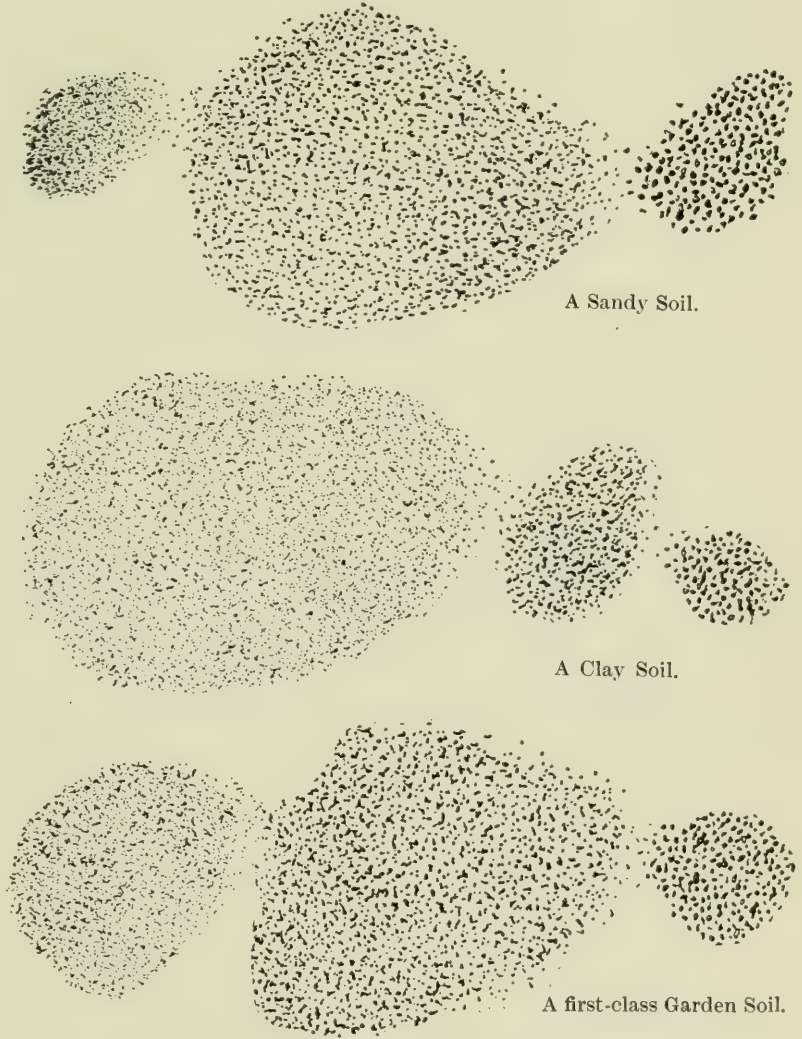


Fig. 5. Showing soils, each separated into fine, medium, and coarse grains.

river below. Upon the gravelly knolls it fell, and trickled quickly down, down, deep into the ground among the gravels and coarse soil-grains, and most of it was soon out of sight and out of reach. It fell, too, upon the clay field, where the soil-grains were all so small and close together that the rain could not find a way between them, and so the rain stood, like little ponds and rivers, in the pits and ruts over the field. Lastly it fell upon good soil, and slowly it soaked away down to the roots of the clover and the corn and the flowers, and down past the roots to a safe storehouse below. Next morning what a change! Even the crops on the hillside and on the gravelly knolls looked fresh and bright. They had kept enough of the rain for one good drink at any rate. On the clay field, the clover stood in danger of having too much of a good thing, for little patches of water were still to be seen here and there. The good soil seemed almost dry again. The corn leaves had straightened out, and every plant in the field was holding its head up straight and strong.

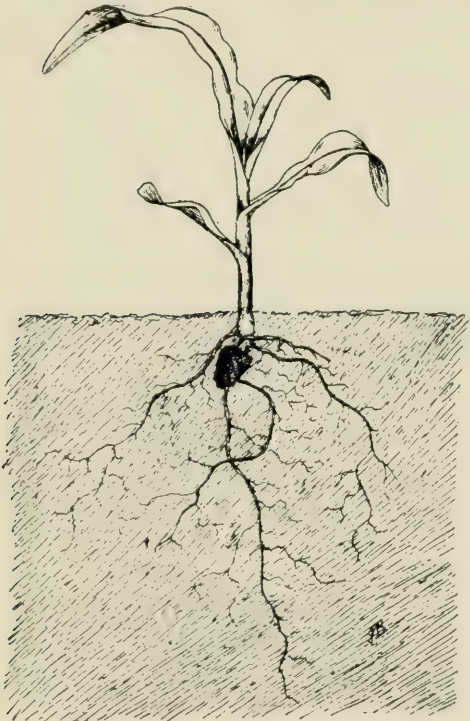


Fig. 6 The Soil and the Seedling.

"The earth all about the roots becomes a scene of life and activity"

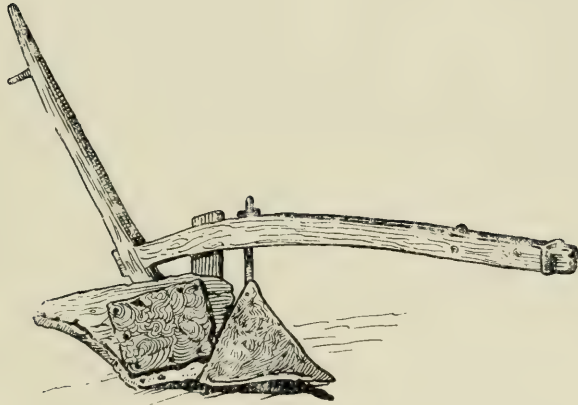
A few days later, and again great changes. The hillside and the gravel patch were in as bad plight as ever,—dry and parched. The wet clay soil, in the hot sun, had dried and baked and cracked, squeezing and breaking the tender roots. The heavy rain and the hot sun had done bad things for this soil, and for its little nursling plants. But on the good soil, the crops had flourished ever since the rain. As soon as the plant roots and the sun had drunk up the moisture at the surface of the ground, the roots sent to the storehouse below the message for more water. The ready soil-grains below the roots began to hand the water from one to another up through two, three, and four feet, to keep the roots supplied with plenty to drink. And so, while the ground above was dry and dusty, the rain that had fallen into the good soil many days before, was still kept on tap, and handed out from below when called for.

THE SOIL AND THE SEEDLING. In every seed there is a possible plant, which will produce many other seeds, food for man or beast. But before the plant can come to life, the seed must be placed in earth. What sort of earth bed does the seed like best? Soft, and moist, and warm. Soft, that is, free of lumps, and fine, and mellow, so that the earth may lie snug and close to the seed; moist, so that the seed may swell and burst, and set the young plant free; warm, so that the little plant may be nursed into life.

Imagine now, the little seedling just peeping above ground, and

sending its thread-like roots down into the soil below. If it is a hard cruel soil, as too many are, it cares nothing for its little nursling, and will very likely let it die. But if it is a kind, good soil, it becomes very fond of the little plant and does all it can to make the nursling thrive. The earth all about the seedling becomes a scene of life and activity. When the plant wants water,—and it is a thirsty little creature,—the sand grains begin to hand the water from one to another till it reaches the little roots. As the water passes by, the humus grains hand out a supply of food and put it into the water. The earth above the roots is all day long drinking in warmth from the sun's rays and handing it down to the roots. When the winds blow and try hard to tear the little plant out, the soil-grains cling hard to the roots and hold them fast in their place. So, you see the soil has all to do with the roots ; what it does is out of sight, and therefore, often out of mind. Yet it is well to remember that the usefulness and the beauty of the grass, and shrubs, and trees come in great part from the earth about below their roots.

The flowers, still faithful to the stems,
 Their fellowship renew ;
 The stems are faithful to the root,
 That worketh out of view ;
 And to the rock the root adheres
 In every fibre true.—*Wordsworth.*



The wooden plow of the early settler.

THE STORY OF PLANT ROOTS.

PROFESSOR MELVILLE CUMMING.

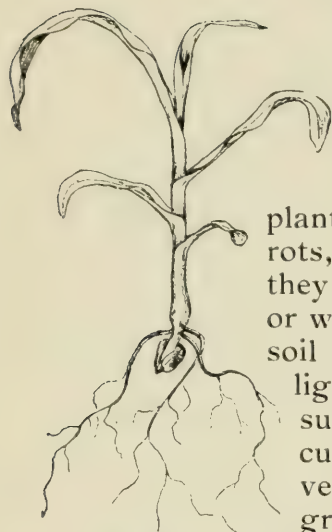


Fig. 7. Corn Seedling, showing leaves, stem, and roots.

Pull up a plant, and you will notice three distinct parts—the leaves, the stem, and roots. The stem and the leaves are the parts above the earth; the roots, the part that is buried in the earth. To the farmer, the roots, being the part in the soil, are in many ways the most important part of the plant. Sometimes he grows such roots as turnips, carrots, and beets for his own use, and then, of course, they are very important; but even when he grows hay or wheat or corn, he can do so only by preparing a good soil in which the roots may grow. With all his intelligence he cannot affect the sunshine and the air which surrounds the stem and leaves; but he can by good cultivation so improve the soil that the roots can develop in the very best way, and by improving the growth of the roots he can improve the growth of the other parts of the plant. Since we are going to study the plant from the farmer's standpoint, we will

dig down into the earth and see what we can of the roots of plants.

What are the roots in the ground for? They hold the plant in place. Have you ever walked against a heavy-blowing wind and felt its force, sometimes so strong that you could scarcely stand up? If you have, you can in part imagine the force with which the wind sometimes blows against a tree that is ten or fifteen times as big as you are. The roots of a large oak or maple or pine tree must be very securely fixed in the ground to stand the great strain from such winds; and although most of the plants grown on the farm are very much smaller than trees, yet even they must be very securely held in the soil by their roots.

Not only do roots serve as anchors, but also as the feeding and drinking organs of plants. Plants, as well as animals, must have food and water in order to live and grow; but, unlike animals, they have more than one mouth through which to take in food and drink. By means of their roots they take in all the water they need and all the food which the soil can give them. However, plants do not get all their food from the soil. Part of it they get from the air, and the leaves are the mouths for this food. It will be very interesting, a little further on, to see why these two feeding organs, the leaves and the roots, are so differently formed.

Yet another purpose do roots serve in the life of some plants. As you all know some plants, called annuals, live only one year. Others, called biennials, live two years; and still others, called perennials, live many years. Plants belonging to the last two classes must have some means of storing up food for the winter months. Perennial plants, such as trees and shrubs, generally develop strong stems and branches and store up food in them. But the stems and branches of biennials and

some perennials die in the autumn, and these plants store up food for their future use in their roots. Some of these with which you are familiar are the carrot, turnip, beet, parsnip, burdock, blue weed, and dandelion. If you pull up any of these in the fall, you will notice that, just next the stem, they have a large thickened root,

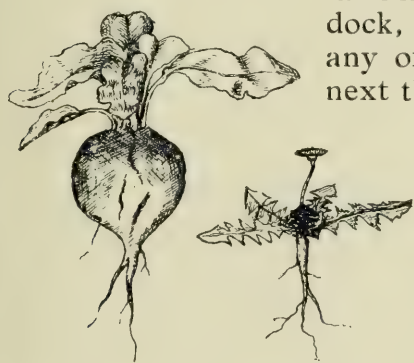


Fig. 8. The roots of the turnip and dandelion.

from which smaller roots branch off. This thickened part of the root is packed full of food to be used by the plant the next spring. Often the farmer takes advantage of such plants and, instead of leaving the roots in the earth for the plant's use next spring, pulls them up in the fall and uses them for himself or for his cattle. Many of you, no doubt, have helped to gather in turnips, carrots, and beets. Some time, when you have a chance, leave a few of

these in the ground and see what becomes of them next summer. Before passing on, I will give you a question to think about. Would you take the same means of destroying biennial and perennial weeds as you would of destroying annual weeds? Some common biennial and perennial weeds are burdock, blue weed, chicory, thistles, plantain, and dandelion.

These, then, are the three uses of roots : 1. To hold the plant in place ; 2. To absorb food and water ; 3. To act as storehouses of food for the future use of the plant.

Now, there is one thing I must ask you to notice before going any further, and that is, that not all parts of a plant beneath the earth are roots. Some plants have stems growing in the soil ; and many people mistake these stems for roots. How many of you, for example, would call the potato a root of the potato plant ? It is not, however ; and if you will compare a potato with a carrot, which is a true root, you will notice some points in which they differ. You have often noticed the "eyes" of a potato. You will not find any such "eyes" in a carrot. These eyes are buds just the same as, though looking a little different from, the ones you have noticed on the stem and branches of a tree.



Fig. 9. Showing the eyes of a potato.

Besides, if you look very closely, you will find little scale-like leaves just beside the eyes. These, however, soon rub off and you may not be able to see them. And then, if you carefully pull up a potato plant on which the potatoes have begun to form, you will find that the branches on which they are borne are not branches of the root but of the stem, appearing just above, that is, in the axil of a leaf. True roots do not bear these buds or leaves, and they never start in the axil of a leaf. The potato is simply the swollen end of a branch of the stem and is called a tuber. Examine in the same way the Canadian thistle, and couch

or witch grass, and see if all the underground parts of these are roots or if some of them are stems.

You have all tried to pull plants out of the ground ; and in doing so, you have noticed that some pull up quite easily and others with much difficulty. Pull up, for example, a corn plant or an oat plant and then pull up a burdock or a clover plant. Why is it so much easier to pull up the corn or oat plant than the burdock or clover plant ? If you will dig down into the earth you will see that the clover and burdock plants have a long main root extending deep down into the earth, and that other smaller roots branch off from this at different depths and extend out into the earth in all directions, whereas the oat and corn plants have no such main root, having only the smaller roots extending out from the base of the stem. Hence the oat and corn plants are much more shallow-rooted than the clover or burdock. If you will pull up a number of plants you will find some like the corn and others like the burdock or clover, some with very deep and others with very shallow roots. This is one of the many reasons why a good farmer grows different crops and not always the same crops, or, as it is called, follows a "rotation of crops" on the same field from year to year. One year he may grow deep-rooted plants, and these will feed upon the food that is deep down in the earth, and the next year he will grow more shallow-



Fig. 10. Showing the tubers arising from the stem and quite distinct from the roots of the potato plant.

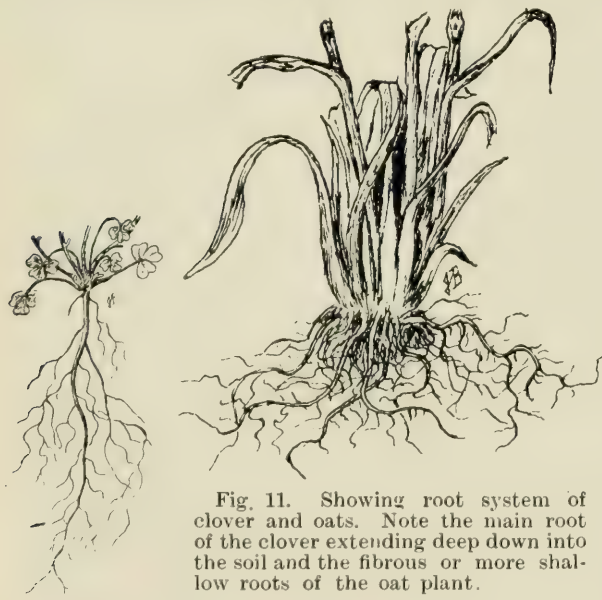


Fig. 11. Showing root system of clover and oats. Note the main root of the clover extending deep down into the soil and the fibrous or more shallow roots of the oat plant.

rooted plants, which will feed in another part of the soil ; and thus the plants are not so likely to use up all the food from any one part of the soil.

This main root, which you noticed in the clover or burdock is called the primary root. The smaller roots growing from the primary root are called secondary roots. These in turn may branch, producing third or tertiary roots, and so on until the whole root system of the plant is formed. When the primary root is very much larger than the secondary roots, as we have already seen in the beet, carrot, turnip, and dandelion,

it is called the tap root. In the case of the corn or oat plant, you will not have noticed any primary roots. As a matter of fact, if you were

to notice the very early growth of one of these plants, you would see a primary root which, however, soon disappears and is replaced by secondary roots springing partly from the base of the stem and partly from the lower joints of the stem. These roots are sometimes called adventitious roots.

But not only will you notice differences in the length of roots in different plants, but you will notice differences in the same plants in different soils. Sow some beet seed in a soil that is not deeply loosened up, and notice how much shorter the roots are than those grown from the same kind of seed sown in a deeply-loosened up soil. This shows you why farmers in growing such crops as beets, turnips, and carrots always cultivate and loosen up the soil as deeply as possible.

Again, trace out the roots of a plant, such as grass, grown in a soil that remains wet for a long time in the spring, and then do the same with a similar grass plant grown in a soil that dries out earlier in the spring. You will find that the roots of the grass grown in the drier soil, have extended down much more deeply into the earth. The reason for this is, that roots are no fonder of cold water to live in than you are, and therefore in a cold wet soil have to spread out very near the surface. In the drier soil they strike down deeply. Now watch the effect when the dry summer days come. The plant on the soil that was so wet wilts away, because its roots are all near the surface and cannot reach down to the water below, whereas the plant in the drier soil, unless the weather becomes very hot and dry, can grow easily, because its roots are down deep in the soil near the water that lies there. Do you not see from this one reason for underdraining fields?

Once more, trace out for a little way the roots of a grass grown in what farmers call a rich, mellow soil, and then do the same in a soil that is poor in plant food. You will find that the roots in the rich soil have branched very much more than in the poor soil. This is because of the large amount of plant food in the rich soil. Have you ever seen people trying to make a lawn? If you have, you will have noticed that, in some soils, the grasses remain in separate tufts and do not mat into a good sod. These are the poor soils. But in a rich soil you will have noticed that in a very short time, not more than a year or two, a good close sod has formed, on which you can easily play croquet or tennis or other games. This is because the roots have developed so much more thickly in the good soil, and thus have produced a better growth of grass, and have become more closely matted together, making a firmer sod.

Now, we have observed a lot of different things about roots. Let us look a little closer at them and see what we can learn about the way in which they push through the soil, how they hold so firmly to it, and how they absorb water and plant food. You have already discovered how very difficult it is to pull up all the roots of a plant without breaking them. When I tell you that the roots of some clovers have been traced

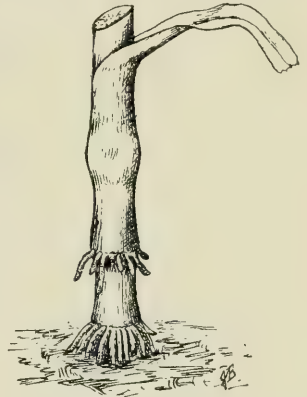


Fig. 12. Showing adventitious roots of corn.

down 30 feet into the earth, and those of some trees 100 feet, you will quickly see that it is not very likely that you have ever seen all the roots of a plant. So if you would know all you could about them, you should grow some plants in your own rooms. Take some bean,

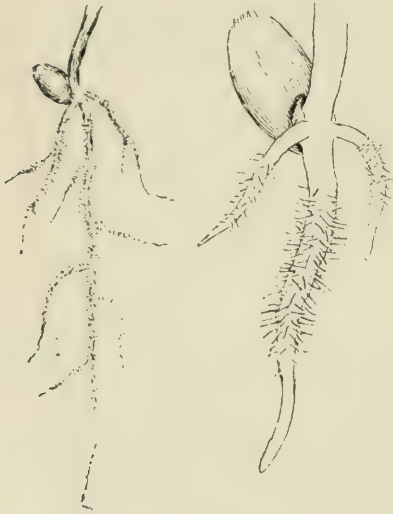


Fig. 13. Showing root hairs on seedling of a bean plant. (a) natural appearance ; (b) some magnified.

pea, radish, or other seeds and place them between folds of moistened black cloth or flannel. Be sure to keep the cloth moist. In a few days the seed will have germinated and the stem and roots will each be an inch or two long. Now notice that, about a quarter of an inch from the tip the root is covered with a fringe of delicate whitish hairs. So delicate are they that if you touch them you will destroy them. These are known as root hairs and they are the feeding organs of roots. It is very difficult to see them in a plant pulled out of the soil, because they have been destroyed by the pulling out. However, if by the greatest care, you can pull out a plant without destroying them you will find these little root hairs near the tips or new parts of all the roots. As the roots grow, the root hairs keep falling off the older parts and new ones grow

on the newer parts. Hence you will see that it is at the ends of their roots that plants take in food and water from the soil, and that the older parts merely serve to carry these up to the stem. How many of you have ever watered trees growing on your lawn or in the garden, and in doing so have poured the water just close to the trunk or stem of the tree where the old parts of the roots grow? If you have, do not forget the lesson you have just learned ; and the next time you water trees, pour the water a little further away from the stem or the trunk, so that it may quickly soak in to where the tips of the roots are growing.

Take one of the little bean plants when the root is about $\frac{3}{4}$ of an inch long, and make small marks upon the root about $\frac{1}{16}$ of an inch apart with a pen dipped in India ink. Wrap the bean in damp cotton wool, allowing the marked root to be free. Fill a small bottle with water and place over its mouth a piece of card board with a hole in it. Hang the bean plant through this hole leaving the root free in the water. Allow it to grow in a dark place two or three days. Take it out and notice the position of the marks on the roots. You will find that the marks near the tip are now at unequal and greater distances apart, whereas those farther back are little changed in position. This shows you that the region of growth is near the tip of the root. This is of great importance in the root growth of plants, because it gives the roots the power to push their way in and out among the particles of the soil,

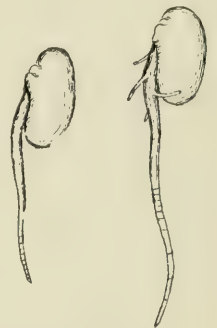


Fig. 14. Showing at (a) the marks on the root of the bean plant. (b) The same marks after 2 days, thus showing the region of growth.

even into the most difficult places. You have noticed that roots are very pliable—easily bent or twisted; in fact, not unlike thread or cord. If the region of growth were some distance back from the tip, the root



Fig. 15. Showing the protecting cap of a root.

would have the same trouble pushing its way through the soil that you would have if you were to try to thread a small needle by holding the thread two or three inches back from the end. I may also tell you, because you cannot see it without a strong microscope, that each root tip has a sort of cap or cushion of cells which protects the true living part of the root in its act of pushing in and out among the particles of soil. Thus, you see, the little roots by being so pliable, by having their growing regions so near the tip, and by having these protecting caps, are well fitted for growing in the soil. If you carefully lift a young wheat or other

plant from the dry earth, you will notice that each rootlet is coated with particles of soil. These stick closely to the root, and it takes much shaking, and even washing, to remove all of them. Thus you see how closely roots, by means of their fibrous branches and root hairs, come into contact with the particles of the soil in which they grow, and hence they have every chance to get all the food the soil can give them, and, besides, become so securely fastened in place that it is almost impossible to pull some plants out of the earth. You remember that in the very first part of our story we wondered why roots should be so different from leaves, which are also feeding organs of plants. You see now that if roots were shaped like leaves they could never hold so closely to the particles of the soil.

Roots are certainly wonderfully adapted to their life in the soil, and, although there are many other interesting things you might learn about them, yet I think you have learned enough this time to make you take a greater interest in even such things as roots; and, I hope also, to make you take a greater interest in the way in which farmers prepare the soil for the roots to grow in.



Fig. 16. A young seedling wheat plant pulled out of dry earth to show how intimately the roots come in contact with the particles of soil.

THE STORY OF A GRAIN OF WHEAT.

C. A. ZAVITZ, B.S.A.

A grain of wheat is very small. It is much smaller than the smallest clay marble that I ever made or that I ever saw. In fact it is so small that a little ant is able to carry it from one place to another. Boys and girls greatly enjoy making clay marbles. They can become very much interested also in trying to make grains of wheat out of clay and water. Even with the greatest of care and the best of success, however, only artificial grains of wheat can be made in this way. No person, either

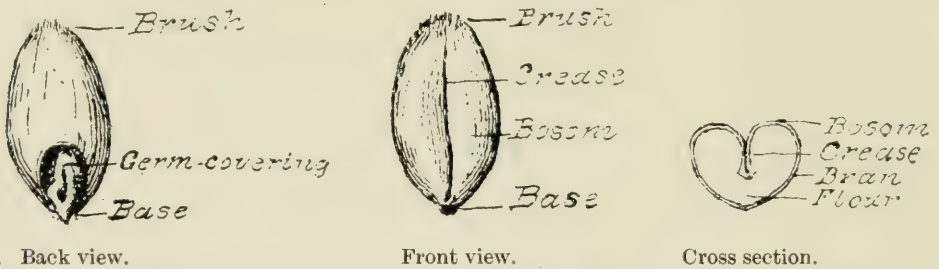


Fig. 17. Back view.

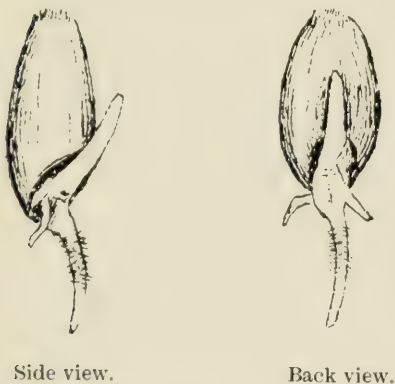
Front view.

Cross section.

young or old, can make a real grain of wheat; yet a real wheat grain is of much greater value and is of far greater interest for the boys and the girls to examine and to study than even the prettiest artificial grain of wheat which was ever made. Allow me to tell you a few of the many interesting things about a genuine living grain of wheat.

An average grain of wheat is about one-quarter of an inch in length, and one-half as wide as it is long. The hairy end is known as the brush and the opposite end is usually called the base. Along the front side is a well defined crease or furrow extending the entire length of the grain.

This crease should be narrow and not very deep. The portion on either side of the crease is called the bosom, which should be large, plump, and rather smooth. The backs of some grains are curved and those of others are actually humped. Most grains have a slightly wavy appearance along the central part of the back, but some are so plump that the wavy appearance is scarcely noticeable. There is still another part to be mentioned, and that is the rough portion near the base and at the back of the grain. This is the covering to the embryo, or germ, or seed proper. The embryo itself can be readily examined if you first soak the grain of wheat in water for about a day, and then carefully remove this covering. A grain of wheat is made up of three principal parts,—the bran, or skin; the endosperm, or flour; and the embryo, or germ. The grain should be plump, the skin thin and nearly smooth, and the germ fairly prominent.



Side view.

Back view.

Fig. 18. Grain of wheat sprouting, four days in ground.

A grain of wheat is made up of three principal parts,—the bran, or skin; the endosperm, or flour; and the embryo, or germ. The grain should be plump, the skin thin and nearly smooth, and the germ fairly prominent.

The great difference between a grain of wheat and a marble of clay lies in the fact that the former has life, and the latter has no life. Nothing can be done to induce a marble to grow. This is not so with a grain of wheat. As long as it is kept in a dry condition, it is simply sleeping. When it is placed in the ground at the right season of the year and surrounded with the proper amount of moisture, heat, and air, it soon awakens. A great change takes place in a very short time. The grain

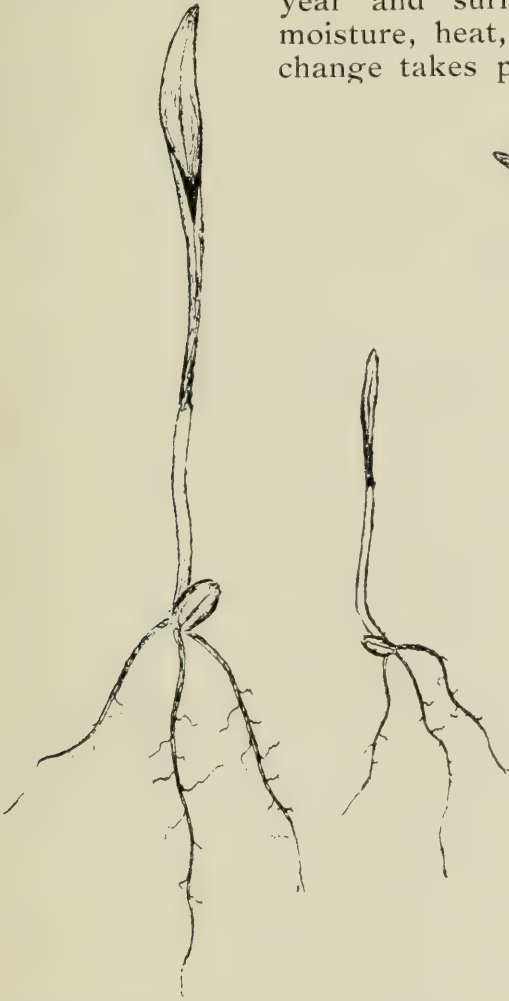


Fig. 19. Plants produced from grains of wheat of different sizes, nine days after planting.

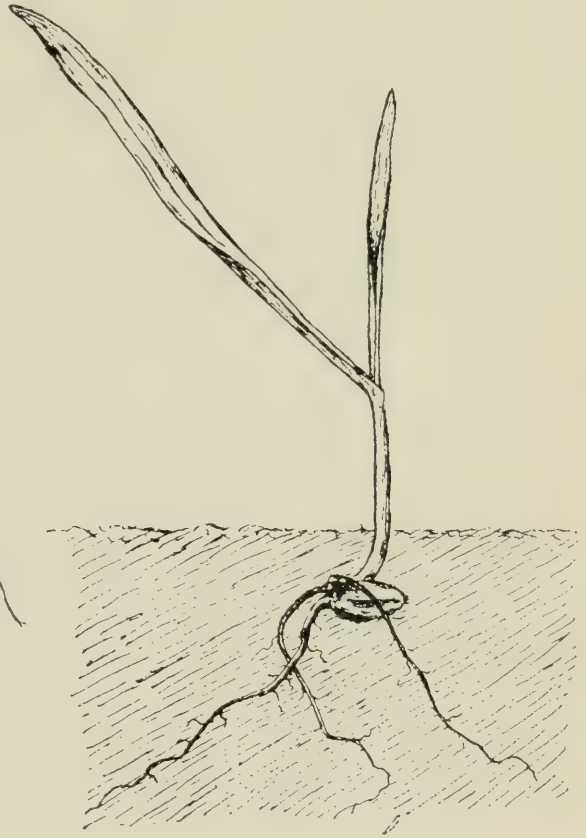


Fig. 20. Young plant of wheat, thirteen days after planting.

absorbs water, the embryo swells and begins to grow, and in a few days a young plant is produced.

The little plant at first obtains its food from the starchy part of the grain. As soon, however, as it sends its roots into the soil and its leaves into the air, it obtains its food from outside sources. The little, fibrous roots get food from the soil in the form of liquids, and the green leaves get food from the air in the form of gases. With the proper conditions, the plant makes a wonderful growth; and, as time passes, we observe the formation of several long, slender, upright stems, with a very interesting and peculiarly arranged head on the top of each.

An average head of wheat is about three and a half inches in length. It is made up of a large number of spikelets which are arranged alternately along the stalk. Each spikelet usually contains three flowers. The flower is small and is enclosed by two glumes, which afterwards form the chaff. These glumes are sometimes blunt and sometimes elongated into awns or beards. The very interesting little flower, therefore, cannot be seen except by opening up the glumes, which



Fig. 21. Head of wheat, natural size.



Fig. 22. Spikelet of wheat.



Wheat flower.

can be readily done by means of a sharp knife or a pin. A small magnifying glass will greatly help in examining the various parts of the flower. The flower produces the seed which at first is very small, but which grows rapidly and ripens in three or four weeks after the formation of the flower.

As the grain ripens, the leaves turn brown and wither, the stems or straws change to a green or lightish yellow color, and the glumes become dry and harsh.

From the one seed which was planted, we have obtained a well ripened plant, which is ready to be cut, harvested, and threshed, and will furnish us with straw, chaff, and grain, all of which are useful.

I have touched on only a few of the points in connection with the life history of the wheat. The germination of the seed; the feeding of the plant; the growth of the leaf, the stem, and the head; the arrangement of the flower; the production of the grain,—are all subjects which are very interesting and worthy of a person's close attention and careful study.

In view of the importance of the wheat crop, a large amount of experimental work has been done at the Ontario Agricultural College in order to glean information which may be of value in increasing both the yield and the quality of the wheat of Ontario. The results of these experiments have been published in bulletins which have been

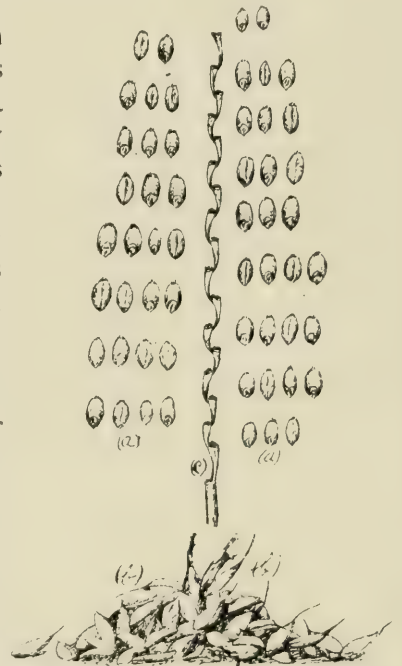


Fig. 23. A head of wheat divided into three parts: (a) the grains; (b) the chaff, and (c) the centre stem.

distributed among the farmers from time to time. Upwards of 300 varieties of wheat have been grown side by side on the College plots. These varieties possess many variations, and may be classified according to the time of sowing, as fall and spring; according to the structure of the chaff, as bearded and bald; according to the composition of the grain, as hard and soft; and according to the color of the grain, as red and white. There are other classifications also, but the ones here mentioned are the most common. Certain varieties of wheat are particularly well adapted for special purposes; some for the production of bread, others for macaroni, and still others for pastry, biscuits, breakfast foods, etc. For making flour, both the red wheats and the white wheats are used; but for the other three purposes, the white wheats are used almost entirely.

For the very best results in crop production, a selection of the most desirable plants from a field of the best variety of wheat should be made. From the grain obtained from these plants, none but the fully-developed, well matured, plump, sound grains should be used for sowing, with the object of producing grain of high quality to be used for seed in the following year.

As we grasp the meaning of the little verse

“ Little drops of water,
Little grains of sand,
Make the mighty ocean
And the beauteous land,”

we can better realize how it is that the little grains of wheat make up the world's production or about two and a half billion bushels, or of Ontario's production of about twenty-five million bushels annually.

Let no one despise the little grain of wheat, but rather let everyone give honour where honour is due, and gladly acknowledge its high position in the vegetable world.

THE STORY OF A LOAF OF BREAD.

PROFESSOR ROBERT HARCOURT.

Every one has seen and handled a grain of wheat. Each little grain is a store-house filled as full as it can be. In each of these little store-houses is everything that is needed to make our bodies grow. Some parts are useful in making bone, some in forming flesh, and some in forming fat, while others are useful in keeping up the heat of the body, and in giving us power to walk and run. Each grain of wheat contains everything that is necessary for all these different purposes. This is one reason why wheat is worth so much money and why we grow so much of it. The people over in England do not grow enough wheat for their own use ; so we grow some for them and send it across the ocean in big shiploads

While we use a large amount of wheat, we do not like to eat it until it has been ground and made into flour. Long ago, when people first began to grind wheat, they crushed it between any two flat stones that

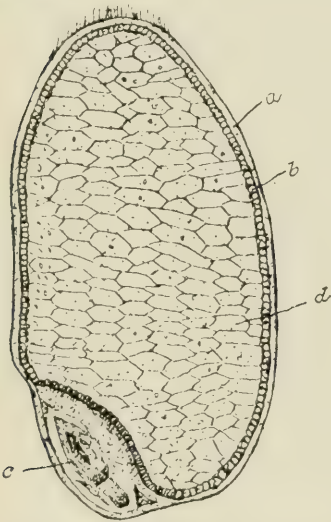


Fig. 24. Longitudinal section of wheat grain. (a) outer coverings ; (b) aleurone cells ; (c) germ ; d Endosperm, the part of the wheat from which the flour is made.

happened to be near at hand. A little latter they kept two flat stones specially for the purpose, one of which was fixed in the ground while the other was turned on it. Methods of grinding in pioneer days are illustrated in Fig. 30. When treadmills, windmills, and, later, water-wheels came into use, the grinding was done at mills by men who understood how it should be done. But in all these ways of grinding, all the different parts of the wheat were left together in the flour. Later, the millers found a method of sifting out the coarser parts.

The grinding of the grain and the sifting of the flour have gradually been improved, until to-day we have mills covering acres of ground, and making thousands of barrels of flour each day. In these mills, they are able to separate the different parts of the wheat, and can make ever so many different grades of flour.

You naturally ask : What is the difference between their various grades of flour ? Are they not all made from the same wheat ? Yes, they are ; but to understand the difference, we shall have to learn something about the different parts of a wheat grain. If we cut a wheat grain through from end to end, and place it, properly prepared, under a microscope, which is a wonderful instrument that makes things look larger than they really are, we shall see something like that shown in Fig. 24. If we were to cut the wheat crosswise, it would appear as in Fig. 25.

Around the outside of the grain, as you see in the picture, there are several thin coverings. Underneath these, there is a row of cells tightly

packed together, called the *aleurone* cells. These outer layers and the row of cells taken together form the greater part of the bran. The little egg-shaped part at the bottom of the first picture is the germ from which the sprout starts when the grain commences to grow. The remainder of the grain, known as the *Endosperm*, is made up largely of starch and gluten. From a miller's standpoint, this part of the grain is by far the

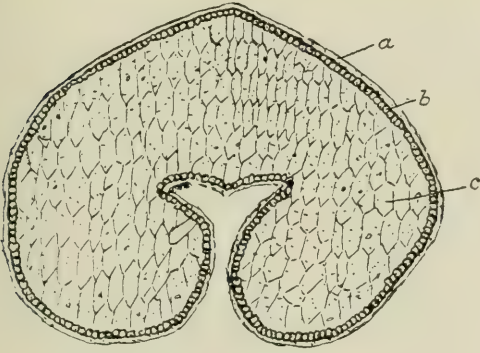
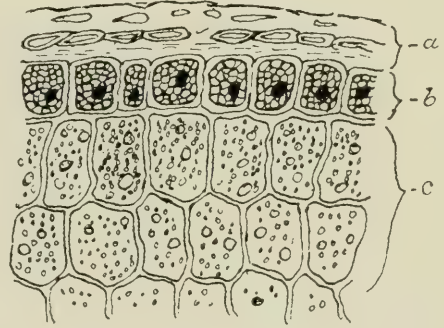


Fig. 25. Cross section of a grain of wheat : (a) outer coverings ; (b) Aleurone cells ; (c) Endosperm, the part of the wheat from which the flour is made.



A part of the section more highly magnified

most important ; for the object of milling is to separate the endosperm from the rest of the grain and grind it to flour.

In the roller-process mills of to-day, the wheat usually passes through six pairs of rollers before the grinding is completed. In the first, the miller seeks just to break the grain into pieces. After sifting, the coarse parts, called the "tailings", are passed on to the next pair of rollers, where they are flattened, and some of the floury substance ground off of them. This is also sifted, and the tailings passed on to the next rollers where the flour is removed. After the wheat has passed through all the rollers in this way, the flattened pieces are almost entirely free from flour, and are classed as bran.

Figure 26 is a picture of a piece or "scale" of bran. In all such methods of grinding wheat, the centre part is rubbed off first ; and, being free from bran particles, it makes very white flour. This forms the grade of flour known as "patent." That got by grinding closer to the bran is known as the "baker's" grades. Still closer grinding forms the low grades of flour. Generally speaking, the more bran particles there are in the flour, the lower it is graded. The outer part of the wheat, nearly all of which goes into the bran, contains much more bone making material than the flour. Because of this, some say that the "patent" and "baker's" grades of flour are not so good as the flour made by the old stone process. The Graham flour is supposed to be all of the

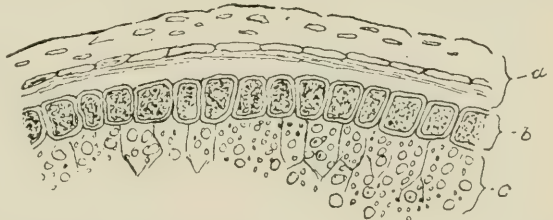


Fig. 26. A cross section of a piece of bran : (a) outer covering of the wheat ; (b) aleurone cells ; (c) endosperm. Notice that the endosperm has not been all ground off from the bran.

wheat ground into flour ; but it is hard to grind the bran so fine that it will not have a bad effect on man's digestive system. To overcome this, there has been invented a machine which peels off the outer coat of the wheat grain. The remainder is ground, and is known as "entire wheat flour." Such flour is always dark in color, because the gem is ground with it ; but it contains more bone and fat producing material than flour made in any other way.

It is very difficult to determine the exact quality of a flour ; but there are certain general rules by which a good bread flour may be judged quickly. It should be white with a faint yellow tinge, and it should fall loosely apart in the hand after being pressed. When put between the teeth, it should "crunch" a little ; or when rubbed between the fingers, it should be slightly gritty. As flour is prepared, possibly there is no one point which determines its quality so much as the amount of gluten it contains. Some one asks : "What is gluten?" Have you ever made

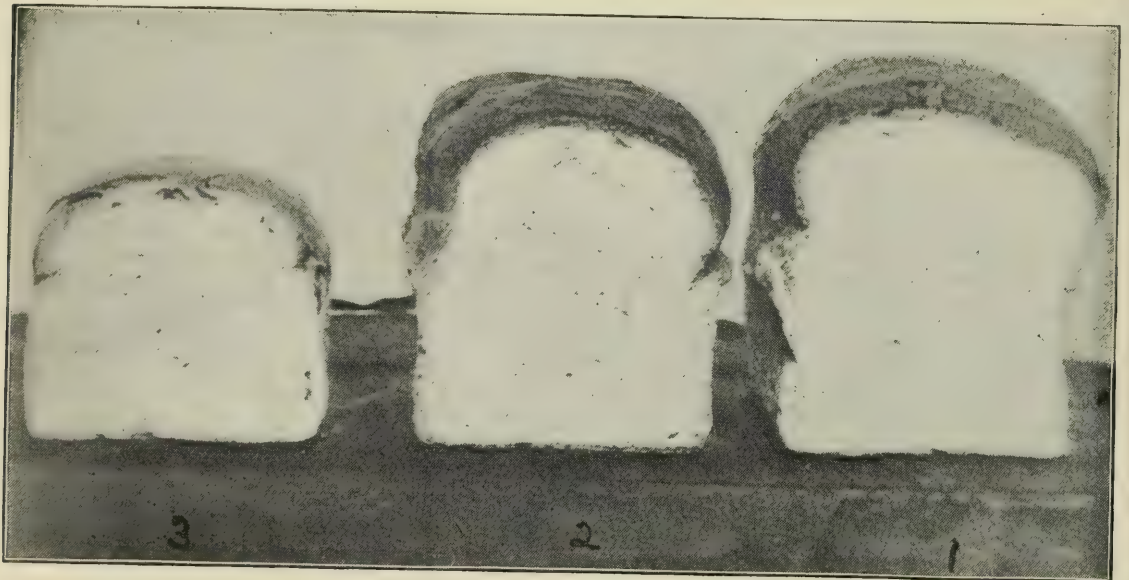


Fig. 27.—Loaves of bread made from equal weights of flour : 1. From Manitoba wheat ; 2. From Wild Goose wheat ; 3. From Michigan Amber wheat.

gum by chewing wheat ? Nearly all children in the country have. The gummy part is gluten. If you have ever tried to make gum from oats, barley, or corn, you have failed ; because these grains do not contain gluten. It is because wheat contains this substance that it is so much used for bread-making. If you take a little flour and add enough water to make it into a stiff dough, and allow it to stand for an hour, and then take it between your fingers and knead it in water, you will see the water get white with the starch that is separating from the dough. Continue the washing until the starch is all removed. What remains is gluten. Notice how tough and elastic it is.

Some varieties of wheat contain more gluten than others. There is also a great difference in the quality of glutens : some are tough and

can be pulled out like a piece of rubber ; others are soft and break when pulled. The wheat which contains the most gluten of a good, tough elastic quality, will make the best flour for bread-making. For this reason, what are known as Spring Wheats are usually better than those known as Fall Wheats. To illustrate this point, flour was made from three kinds of wheat—Michigan Amber, one of our best winter varieties ; Wild Goose, a very hard Spring variety ; and Manitoba, No. 1, hard. These flours were made into bread and a loaf of each lot was photo-

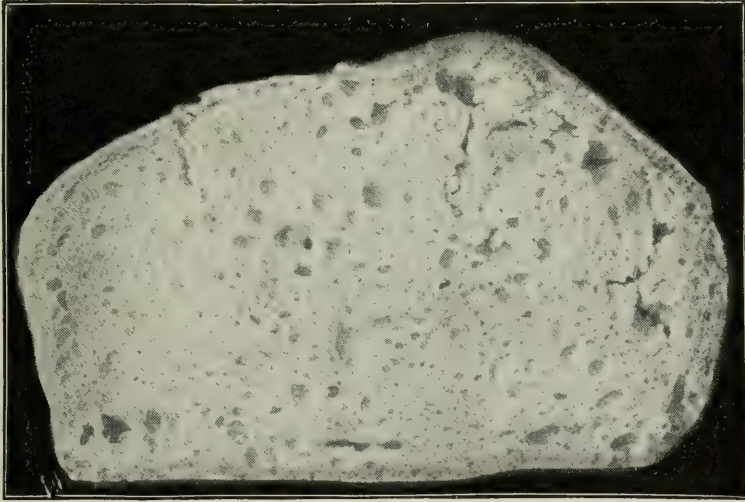


Fig. 28 —Loaf of bread made from normal flour from which part of the gluten had been removed. Note the big cracks up through the loaf, from which the gases escaped without causing the dough to rise.

graphed. The same weight of flour was used for each loaf. Fig. 27 shows the difference in size of the loaves. Manitoba flour made the largest loaf, because it contained more and better gluten than the others. Millers call a flour which contains good gluten, "strong," and one that contains poor gluten, "weak."

Now that we have learned something about flour, let us see if we can learn something about the changes that take place when it is made into bread. If you have ever tried to wet flour with water, you will have noticed how hard it is to get the flour all wet. That is because the flour is so very fine. One of the main objects of making the flour into bread before it is eaten is to separate these fine particles, so that the digestive fluids of the stomach may more easily mix with them. The baker commences by mixing the flour with water. He also puts in yeast, or something which will produce the same effects, and mixes it all together so thoroughly that the water and yeast come into contact with each little particle of flour. When the paste, or dough, containing yeast, is set in a warm place, the yeast begins to "work," as we say, and the dough to "rise." The yeast causes changes, one of the principal results of which is the production of a gas. This gas, in trying to force its way through the dough, comes into contact with the tough elastic gluten which spreads out and holds the gas in so as to form little bubbles, and thus causes the dough to rise. In



Fig. 29.—Loaf of bread made from normal flour.

this way, the fine particles of flour are separated from one another. The tougher and more elastic the gluten, the better the dough will rise, and the lighter the bread will be. This is where good gluten is valuable.

Take a slice of bread and examine it carefully. Notice the little openings or holes in it. These little holes were formed by the gas being held in by the gluten as just described. If too much yeast is added to the flour, too much gas will form, and the openings will be very large, or the gas may even spread out the gluten so far that the walls of the bubbles will break. If the gluten is all or partly removed from the flour, the dough will not rise, because there is nothing to keep the gas in, and we shall have a loaf like that shown in Fig. 28 and 29.

After the yeast has worked enough, the dough is put into a hot oven. Here the heat kills the yeast and causes the gas to expand and stretch out the walls of the little bubbles, or pockets, which it formed between the particles of dough, and changes some of the water into steam, thus raising the loaf still more. The heat on the outside of the loaf converts some of the starch into *dextrin*, a gummy substance with a sweetish taste. This is why the crust is sweeter and tougher than the centre of the loaf. The harder the loaf is baked, the darker the color, through the changing of some of this dextrin into caramel, which is a form of sugar. Some bakers moisten the top of the loaf with water, or water containing a little sugar, to develop caramel, and to give the loaf a darker and richer color. Both dextrin and caramel are soluble in water; and, therefore, they are easily digested. This explains why the crust of bread and toast are sweeter than the soft interior of the loaf, and also why they are more easily digested.



Fig. 30, In Pioneer days.

THE STORY OF THE YEAST PLANT.

PROFESSOR F. C. HARRISON.

We have all heard of yeast, but perhaps, not very many know that yeast is a plant—a very different plant, however, from what we usually see. It has no stems, no leaves, and no roots; it is not even green; it is so small that a single plant cannot be seen by the naked eye. In order to see it, we must use a powerful magnifying instrument, called a microscope. If we examined a yeast plant by means of a microscope, we should see that full grown plants were round, oval, or egg-shaped, and so small that 5,000 of them placed end to end would be about an inch long. Figures 31 and 32 will give some idea of the shape of this plant, and convey a hint as to its size, as the illustrations are photographs of yeast plants magnified 1000 times.

Most of us eat bread every day; but only few of us stop to think that we are indebted to the yeast plant in a large measure for the flavour and digestibility of the "Staff of Life." The baker kneads, or mixes, his flour, water, and yeast and then leaves it in a warm place, which favours the growth of the yeast. In a very short time, the yeast begins to grow by feeding upon the sugar in the flour, and in so doing changes the sugar into alcohol and a gas, commonly called carbonic acid gas, which is familiar to us all in ginger ale and other aerated drinks.

The gas formed from the decomposition of the sugar by the yeast plant in the dough, is unable to get out, owing to the sticky nature of the kneaded flour. It is held in small bubbles, the form of which can be seen on looking at a piece of bread, the small holes being the spaces which are made by the gas bubbles in the dough. The heat in the oven acting upon these bubbles causes them to expand, or grow large, and thus pushes the particles of flour apart, so that the loaf when baked is much larger than the piece of dough before baking.

The alcohol, a liquid formed, as stated above, by the yeast plant acting upon the sugar in the flour, may be smelt, if an opening is made in the dough when it has risen; but most of this substance is evaporated, or driven away, by the heat in baking, and only a very little of it is retained in the bread.

Thus we see that by the action of the yeast the particles of flour are divided and subdivided, giving a large surface for the digestive fluids to act upon when the bread is eaten; and for this reason, bread is more digestible than cakes made with baking powder or sour milk and soda.

The use of yeast for making bread is very old. We know that the Jews were acquainted with the use of "leaven," or yeast; for we read that Lot "did make them a feast and did bake unleavened bread."

And the use of yeast for making wine is even more ancient; for we learn that Noah, the second father of mankind, planted a vineyard and made wine.

The Chinese also knew of the use of yeast for bread and wine making; for about the year 2000 B.C. Ching NOUNG, a Chinese philosopher,

taught the Chinese the art of husbandry, and the method of making bread from wheat, and wine from rice.

In the process of wine making, the grapes, as soon as they are picked, are carried to a suitable vessel and there pressed. The juice of the grape, called "must," together with the skins, is then placed in a large vat; and the yeasts, which are always present on the surface of ripe fruit, begin to grow, and in their growth produce alcohol and gas. This production of alcohol is called the first fermentation; and when it is nearly over, the wine passes through a strainer into a cask to undergo the second fermentation. This cask fermentation lasts for several months, and during this time flavouring substances are formed which give the aroma, or *bouquet*, to the wine. The high price of certain wines is due to the excellency of their aroma, which is largely a product of the yeast-plant.

Sometimes injurious forms of yeast get into wine, and cause wine diseases. One of the commonest is a yeast-like plant which changes the alcohol into vinegar, and gives the wine a sour, or vinegar, taste.

Cider and perry may be regarded as the wines of those districts in which the grape does not flourish. Cider is the juice of the apple fermented with yeasts that are naturally present on the surface of the fruit, and perry is the fermented juice of the pear.

Barley, yeast, and hops are used in the making of beer. The barley is allowed to germinate, or sprout, in order to change the starch of the kernel of the barley into sugar. This material, extracted by means of hot water, is the food in which the yeast plant grows and produces alcohol and carbonic acid gas.

Other substances are used to give flavor to the beer; but the essential part of the making is the changing of the sugar solution into alcohol by means of the yeast plant.

Special varieties of yeasts are used to make different kinds of beer, as ale, lager beer, etc.; and, as in the case of wine, disease-producing yeasts very often appear and produce a cloudy, or turbid, liquor, which is disliked by those who use such drinks.

From a study of the changes in bread, wine, etc., we see that the yeast plant, in order to grow, requires a proper supply of food, which should consist of a mixture of nitrogenous substances, a certain amount of carbon (usually supplied in the form of sugar), and also mineral matter. About 20 per cent. of water is also necessary, and a suitable temperature, between 60 and 90 degrees Fahrenheit. If these conditions are present, the yeast-plant is able to live, grow, and produce other yeast-plants.

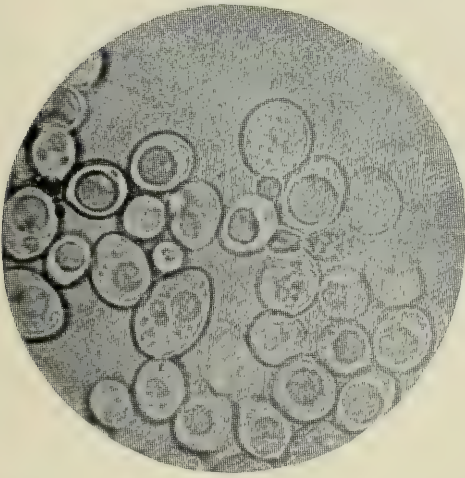


Fig. 31. Full grown yeast plants greatly magnified, the natural size being only one-thousandth-part of the size shown in the figure.

The yeast plant consists of a single cell, which, at a certain stage, sends out a bud from some part of its surface, which gradually increases in size. This bud may or may not remain attached to the parent stem. If it does so, and the old stem continues to send out more buds, a mass of cells is soon formed; but, if each cell as it grows produces a bud, a long chain of cells is formed.

Under certain conditions (moist surface, plenty of air, favorable temperature, and strong cells), small round bodies from two to eight in number are formed inside the old cell, which are called *spores*. These may remain dormant (that is quiet or asleep) for a considerable length of time, but will germinate when placed in suitable food. They are usually more resistant than the cells in the growing condition. Even the



Fig. 32. A wine yeast, showing spore formation,—magnification, 1 000 diameters. From 2 to 4 spores may be seen in most of the cells.

ordinary cell lives for a considerable length of time when it is kept dry; and the dry yeast cakes, which are sold for bread-making purposes consist of dried yeast cells mixed with starch or ground corn.

There are several hundred varieties of the yeast plant, possessing different properties, as there are many varieties of apples; and as some kinds of fruit are better than other kinds, so some varieties of yeast are more suitable for use than others.

Yeasts of different varieties are used in the manufacture of liquors, such as beer, whisky, wine, cider, etc., and any of these yeasts could be used in bread making; but some would require twelve to fourteen hours to raise the dough to the same extent as another would in seven or eight hours. Figure 33 shows that some varieties of yeast produce more gas than others. Thus, the variety in number 1 tube would be more

valuable for a baker than the one in number 3 tube, because it produces more gas ; but this variety would not be suitable for other purposes,—say for the manufacture of wine.

In the same way, a yeast used for the making of champagne would not be suitable for making beer ; and such is the influence of the yeast on the flavour of the product, that very good imitations of certain wines may be made by growing in apple juice the yeast taken from the wine.

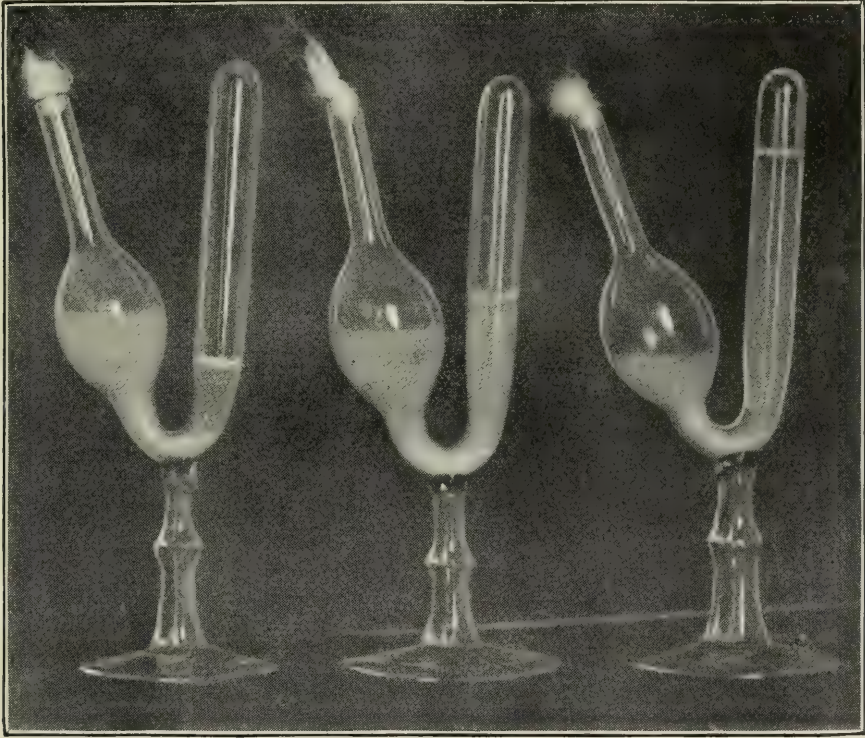


Fig. 33, Fermentation tubes containing flour and water—
 1. With addition of a distillery yeast.
 2. " " brewery yeast.
 3. " " dried cake yeast.

Note, in the right arms of the tubes, that there is more gas in 1 than in the others, showing the more energetic working of the distillery yeast. For the same reason, there is more gas in 2 than in 3.

The injurious yeasts are also quite numerous. Besides those we have already spoken of, we might mention those that produce bitterness, not only in wine, but occasionally in milk and cheese. These yeasts grow in milk, feeding upon the milk sugar, changing it into other compounds, and giving rise to an unpleasant bitter taste, which affects, not only the milk, but the cheese made from it.

THE STORY OF A POUND OF BUTTER.

PROFESSOR H. H. DEAN.

Mrs. Boss and her neighbors agreed to hold meetings throughout the winter, when not busy. They also decided to discuss buttermaking at the first meeting, and this is what a man who understands cow talk heard them saying :

MEETING NO. I. The first to speak was Mrs. Brindle. She said that it was her candid opinion that all his talk about "pedigrees" and "butter-blood" did not amount to very much. She thought that if her

owner would look around he could find, among her friends plenty of good cows for making butter, which had not any papers to show their breeding. For her part, she considered that blood was of no account. What she wanted was a cow that could *do* something.

Mrs. Black - and - White, known in higher cow circles by the name of Mrs. Holstein-Friesian, or Mrs. Holstein for short, said she considered that it was better to give a large flow of milk, so as to have plenty of skim-milk for the calves and pigs, as well as what is used for buttermaking.

Some of the other cows thought that there was too much to handle to get a pound of butter from such milk. Mrs. Canadian said that some poor farmers could not raise enough feed to satisfy the appetite of the previous speaker, and she believed that a small cow, which is a small eater, is best for a poor man.

Mrs. Shorthorn, who also belongs to the high class in cow society, argued in favor of the cow that gives milk to drink, and butter to eat ; and if not satisfied with that, her owner could turn her into beef. Some of the members remarked that combined machines never work so well as special ones.

Mrs. Ayrshire said that, as the discussion was on butter-making, she had little to say, though some of her relations were just as good for butter as any cows.



Fig. 34. Holstein.



Fig. 35. Shorthorn.

Miss Jersey and Miss Guernsey both spoke at once, and stated most positively that milk rich in fat could be most profitably turned into butter. Such milk made butter with the golden color, and the firm texture in hot weather. They also said that it did not cost the owner so much for the

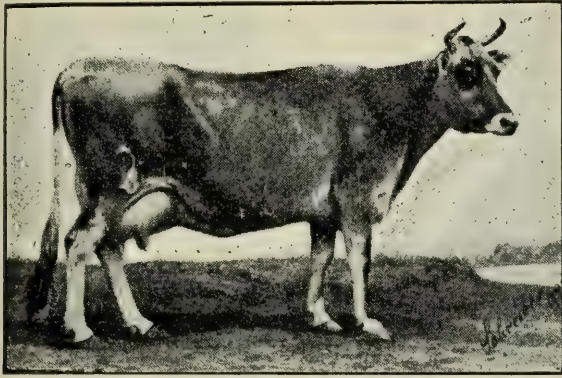


Fig. 36.—Jersey.

feed to make a pound of butter, and pointed to "official tests" to prove their statements.

At this point the other cows began chewing their cuds so vigorously that it was thought advisable to adjourn the meeting.

No. 2. At the next meeting, it was resolved to discuss "feeding for butter," and the only speaker on this occasion was Old Mrs. Lineback, who had many years of experience "browsing" and running around straw-stacks in winter, and eat-

ing in fence corners and along dusty road-sides in summer. She had also tried these new-fangled feeds, called silage, gluten meal, cottonseed meal, and the like, but her experience was that there was nothing equal to good, sweet June grass for making butter. When the grass is short and somewhat dry, she advised feeding green peas and oats, or a small quantity of sweet silage, together with bran and oats. In winter, clover hay, sweet silage, mangels, bran, oats, and peas make excellent foods for producing butter. She would also emphasize the importance of plenty of pure water and salt as aids to digestion, and necessary for a good flow of milk.

With these statements, all agreed, and there was no further discussion.

No. 3.—The third meeting was a sort of "indignation meeting." The chief speakers on this occasion were Miss Jersey and Miss Guernsey. They both protested against being awakened from a pleasant nap at half-past four on a winter morning. So far as they were concerned, they did not see any reason for their owner waking his wife and children from a sound sleep at that hour, then tramping to the stable with a lantern, whose bright

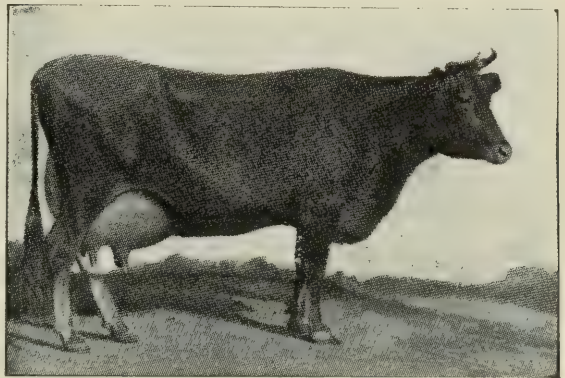


Fig. 37.—Guernsey.

light hurt their eyes very much, and *they were sure it was spoiling their beauty*. They would much prefer having their owner not awaken them before daylight, as they did not believe it wise to be eating in the dark when they could not see what was going into their mouths. The quantity

of milk in their udders never hurt them, if it was a little longer time between night's and morning's milking. They had also observed that whenever the Hired Man had to attend to them and do the milking at five o'clock in the morning, he was usually in a bad temper. He pinched their teats, and sometimes hit them with the stool, which made them feel cross and they did not give so much milk, nor did they put so much fat into it. Mrs. Holstein and Mrs. Ayrshire said, in their case if

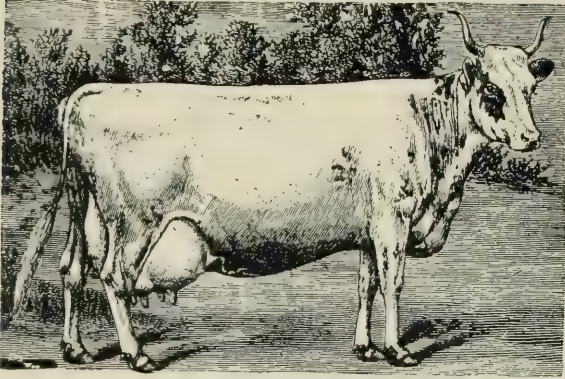


FIG. 38.—Ayrshire.

they were not milked at regular hours and the same number of hours apart, that the milk in their udders hurt them, and they would enter a strong protest against the views expressed by the previous speakers. When, however, they gave less than two gallons of milk a day, they said it did not make so much difference to them about milking exactly the same number of hours apart

Mrs. Tidy-Cow said she would like to make a very strong complaint against being milked in stables where the air was foul, where she could not keep herself clean, and against owners who made no effort to improve the cow-houses in winter. She had found that it was better for the person, when milking, to wipe the udder and teats with a clean, damp cloth, before commencing to milk, and to milk with dry hands especially in winter. She believed in milking quickly, milking out clean, and kind treatment at all times, especially while milking, as this caused the cow to give more milk.

Mrs. Cow-Curious would like to see a milk-sheet, scale, and test-bottle in every stable, so that she could see what her neighbors were doing.

All agreed that it would be excellent, if each one could know how much milk and butter her neighbors gave in a year. Now that their curiosity was aroused, it was resolved to find out how their milk was made into butter; and, if at all possible, they would go into their owner's dairy, and watch operations.

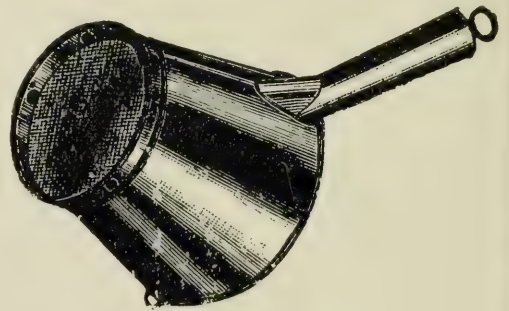


FIG. 39.—Cream Strainer.

No. 4.—The next meeting was held in Mrs. Busy's dairy, soon after milking. As there were no chairs suitable for the guests, each one stood on the floor of the dairy, being careful not to get in the way. It was also agreed that they talk very little during the visit to the dairy, but keep their eyes open and see what was done with the milk which was to be made into butter.

They observed that the first thing which Mrs. Busy did was to strain the milk through two or three thicknesses of cheese cloth and a fine wire strainer, to remove any dirt that might be in the milk.

Some of Mrs. Busy's customers, it was explained to the visitors, liked butter made from cream set in shallow pans, some liked it made from cream raised on deep cans set in ice water, and some would have nothing but separator butter. So all three methods were in use. Mrs. Boss and her neighbors noticed that the milk from Miss Jersey, Miss Guernsey, and Mrs. Canadian were set in shallow pans and deep cans, because the milk from these contained fat in the form of good-sized globules (balls) which rise readily. The milk from the others was all run through the separator, which is a machine with a bowl that revolves very fast, producing centrifugal (flying from the centre) force. The heavier skim-milk is forced to the outside of the bowl, and the lighter cream comes towards the centre. The sweet warm skim-milk is fed to calves and pigs, and the cream is put in a can to ripen (sour), after being cooled to 65 degrees. The visitors noticed that some sour milk (culture) of good flavor was added to the cream, which was for the purpose of producing good flavor in the butter, especially in winter. The cream was then put into a moderately warm place until next day, when it would be ripe and ready to churn.

In the meantime, their owner's daughter, Miss Busy, had washed the separator and the milk pails, and everything was in nice order for the day.

After apologizing for the tracks made on the floor of the dairy, Mrs. Boss and her neighbors went back to the stable, having learned a great deal.

As they were leaving the dairy, Mrs. Ayrshire became excited and switched her tail into the cream can, for which breach of good manners Miss Jersey and Miss Guernsey gave her a very severe look which almost made her horns turn down.

No. 5.—As soon as the morning work was done at the farm house, the churning completed and the butter from the separator cream was ready for market, Mrs. Busy went to the cow-house to finish her explanations; because, as she said, she never could churn and get the butter ready to go to market in time when she had a lot of visitors. Besides, visitors were a nuisance in the dairy, for they were always in the road and were poking their noses into everything.

She began by saying that the milk set in shallow pans must be kept *cool*, and be set in a clean dry cellar, or milk-house, where no bad flavors can get into the cream. In twenty-four hours in summer, and thirty-six to forty-eight in winter, the pans are ready to cream (skim). This is done by running a thin-bladed knife around the edge of the pan to loosen the cream. (Mrs. Line-Back said she had always seen this done with a finger. Mrs. Busy explained that this was not a very clean way to loosen the cream, and that a knife was much better) The cream is then held back with the knife to allow some skim-milk to moisten the edge of the pan, which prevents the cream sticking to the tin. The cream is then guided into the cream-can with as little skim-milk as possible.

(At this point, Mrs. Brindle interrupted to say that she had always heard of a strainer skimmer being used for taking cream from pans, but she could see now that it caused a waste of the cream and was not good practice. "We are always learning!"). The shallow pan cream is then set in a cool place until there is sufficient for a churning, when it is brought near the stove to ripen (sour) for twenty-four hours.

Cream on deep cans (Creamers) may be removed from either the top or the bottom of the cans. The milk should be set for 12 to 24 hours in summer, and 24 to 36 in winter for the cream to rise on milk set in deep cans. Mrs. Busy also explained that it is necessary to cool the milk as rapidly as possible to 40 degrees, or not more than 45 degrees as soon as convenient after milking, by using ice in the water. And, by the way, she said that every person who makes butter should use, not their finger, but a good glass thermometer to find the temperature. The cream is kept in a cool place; and, when there is enough for a churning, it is warmed and ripened in the same way as cream from shallow pans.



Fig. 40.
Thermometer.

The ripening (or souring) of cream is a very important point, as this largely decides the flavor of the butter. The ripening is caused by very small plants (called bacteria) which grow in the cream. It is important to have the right kind of bacteria seed to put into the cream, so as to get proper plants and proper flavor.

Good seed may be bought, or it may drop into the cream from the air. It is best to buy the seed in pure form at first, then grow the plants in pure skim-milk. Add some of this to the cream at each churning, but keep some to put into fresh skim-milk each time. This you must know is the great secret of nice flavor in butter.

(Mrs. Brindle said to her neighbor that she did not take much stock in the "seed" business. She had observed that at most of the places where she had been, the farmer's wife just let the cream take "pot-luck," and most of the time the butter could be eaten; and, if it couldn't, her owner could always trade it at the store for crackers and tobacco.)

Mrs. Busy did not take much notice of this talk of Mrs. Brindle's but went on to explain how to tell when cream is ripe. She said: Use your eyes, and see if it is thick, glossy, and velvety in appearance; use your tongue, and if it tastes slightly sour, it is ripe. Use your nose, and, if it smells pleasant, it is ready to churn.

Churn rich separator cream at a temperature of about 50° to 52° in summer, and 52° to 56° in winter. Cream from cans and pans should be from four to eight degrees warmer than separator cream as a rule.

We must leave the talk about churning until next day, as I hear Tommy calling for his mother.

No. 6.—Quietness reigned in the stable next day when Mrs. Busy continued her story of a pound of butter:

The best churn is a simple box or barrel, which is easily kept clean. These new style air-churns and churns with patent dashers are no improvement. First, scald the churn to fill the pores of the wood with

water, to prevent cream and butter sticking to it, and then cool with cold water. The cream should be strained through a coarse strainer into the churn to prevent "specks" in the butter. If coloring is used, put it into the cream at this stage. Close the lid firmly and turn the churn at the rate of 60 or 70 turns per minute. Allow the gas to escape through the opening at the bottom of a barrel or box churn for a few times during the first ten minutes. Continue churning until the butter is the size of wheat-grains; then draw the buttermilk off through a strainer.

(Mrs. Boss remarked to a neighbor that she had always seen the butter churned into a lump, or until the dasher would stand on top of the butter, before taking the butter out of the buttermilk in the old dash churn.)

When the butter will not "come," said their Instructor, it is chiefly because the temperature or heat is not right. Cream which is difficult to churn will nearly always "come" after warming to 70° or 74° and churning for half an hour.

After the churning is done, add as much water at a temperature of 45° to 50° in summer, and 55° to 60° in winter, as there was cream at the beginning. Then revolve the churn rapidly for about two minutes and draw off the water. Allow the butter to drain for 10 to 15 minutes; then add fine butter salt at the rate of about one ounce of salt to a pound of butter in the churn; or remove the butter to a lever worker and add the salt. Work the butter gently with a downward pressure, until it is free from moisture on the outside, until it is close in appearance, and until the salt is all dissolved. I wish, said Mrs. Busy, to impress upon you the importance of preparing the butter for market in a neat and attractive manner. Use a wooden printer to mould the butter into oblong prints, weighing one full pound, or a little over, then wrap them in parchment paper, having the name of the dairy neatly printed on the wrapper. Put the butter in a cold place, and send to market once a week in a neat shipping box. In summer, use ice in the shipping box to keep the butter firm. Always send the butter to market with the best looking and neatest person on the farm. *Send none but the finest butter to regular customers, and be very careful of your reputation,* were the last words of the teacher.

No. 7. To-day we shall try to learn what it is that makes good butter, said Mrs. Busy in her last talk. *Flavor* is the most important thing in good butter. Cream which is kept too long (more than three or four days) before churning makes butter which has an "old" flavor. The food which a cow eats also affects the flavor of the butter. Turnips, brewer's grains, decayed silage, and some weeds always taint butter. Butter with good flavor should have a pleasant, sweet taste and smell, and should make the person eating it wish for more.

The next point is the grain, or texture, which should not be too hard, nor yet too soft or greasy, or salvy. Butter should spread nicely on bread, and then it is nearly perfect in texture. The color should be even—free from "mottles," white waves, or streaks. Streaks in butter are caused by improper working. It should not be too yellow, nor yet too white for home markets.

The amount of salt in butter should be according to the taste ; but it must all be dissolved, and the butter must not be "gritty." This grittiness is caused by using too much salt or by using coarse salt.

The package should be neat, attractive, and stylish, so as to please the eye of the customer.

Such butter will be eaten much more readily than poor butter ; and we wish people to eat as much as possible, you know, said Mrs. Busy.

Clean, sweet butter is one of the most easily digested fatty foods, and all persons should have plenty of good butter on their tables.

This finishes our lesson on a pound of butter, and I hope that you now know something about how butter is made, and that you will take more interest in your business of making milk for butter.

Mrs. Boss and all her friends bawled their thanks of appreciation for the instruction given. All were of the opinion that if owners of cows would take more interest in them, talk to them as friends, share their secrets with them, and give them more encouragement, as well as more to eat, cows would give more milk, which would make more butter, which would bring more money, which would enable boys and girls to have a greater number of nice things in the home on the farm.

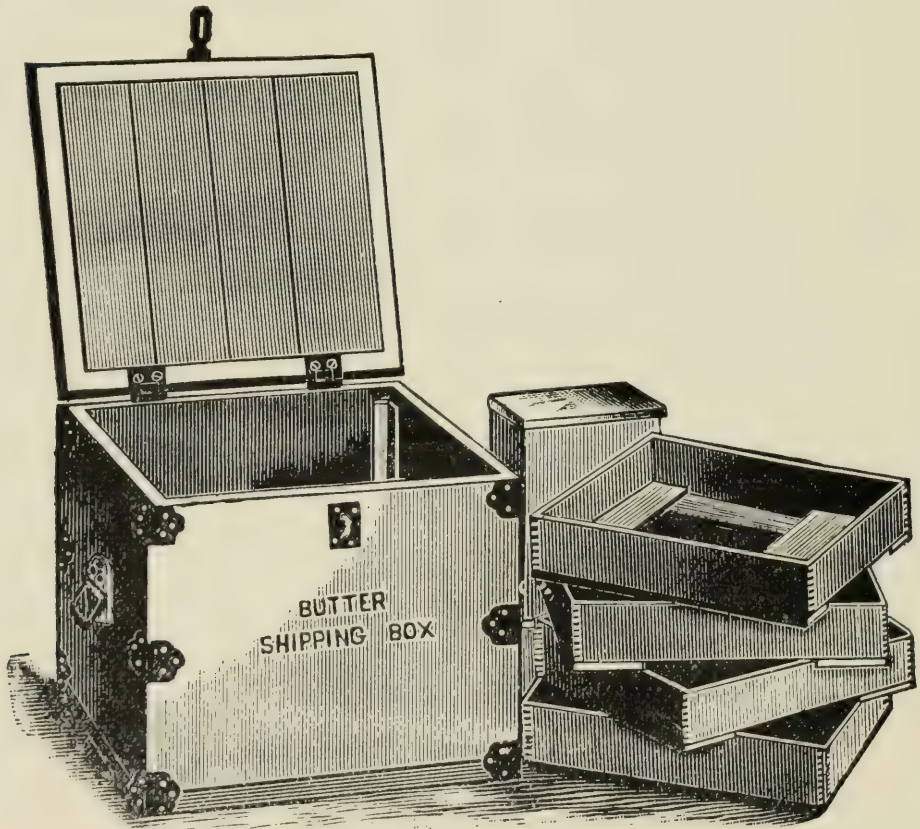
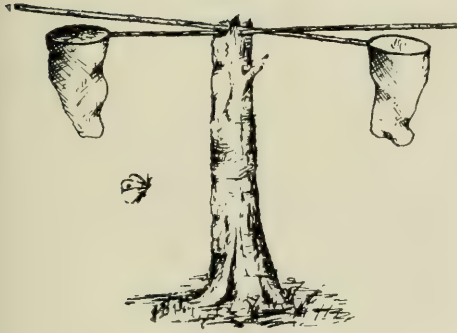


Fig. 41.—Shipping Box for Butter.

THE STORY OF THE CABBAGE BUTTERFLY.

PROFESSOR W. LOCHHEAD.



THE White Cabbage Butterflies can be seen almost any fine day in summer flitting about the cabbages in the garden, and among the wayside flowers. Although harmless, they are not liked by farmers and gardeners, because they are the parents of the common green "worms" which do much harm to cabbages by eating holes in their leaves.

It seems strange that a green, crawling cabbage worm should grow into a dainty, white-winged butterfly; and it is the object of this story to tell, in a simple way, the strange life of this insect. It must be remembered, however, that the life stories of all insects are not alike. Some insects spend their whole life above ground; some partly below ground and partly above; some almost altogether in water; some partly in the water and partly in the air; some eat their food as a liquid; some spend part of their life as a crawling caterpillar, while others have no such stage. So varied are the habits of insects that a noted writer once said:—"Insects walk, run, and jump with the quadrupeds, fly with the birds, glide with the serpents, and swim with the fish."



Fig. 42—The boy and the insect.



Fig. 43—Egyptian Mummy in its case.

It would be interesting work to find examples of many of the insects to which this writer referred, and to study their habits; but this story must deal with the White Cabbage Butterfly.

The ancient Egyptians had a strange custom of embalming their dead, and wrapping them in linen bandages. These mummies, as they are called, were placed in curiously wrought cases, and stored carefully away in secret tombs or pits, in the belief that after a time life would return to them.

Now we have creatures which nature changes into *living mummies* for five or six months in the year; and living mummies ought to be more interesting than dead ones. These may be seen at any time during the winter if a little search be made for them under fence-rails, under the eaves of outbuildings, and in other sheltered places. I mean the pupae, or resting forms, of insects. But the particular mummies to which I shall refer are the chrysalids (Fig. 44) of the White

Cabbage Butterfly, which are usually abundant in late autumn on fences about cabbage gardens and turnip fields. If one of these chrysalids be examined, it will be seen how carefully the tongue, feelers, and legs are folded over the breast and tightly packed together within its "mummy" case.

But of all the chrysalids which are alive in the fall, only a few are living in the spring. For many years observers have noted this fact, and my custom has been to prove it for myself every spring. My walk this March afternoon was back along the farm lane, where I have always found chrysalids in early spring. I knew exactly where to look for them, for I had watched the full-grown caterpillars, or "worms," last autumn leave the cabbage, turnip, and rape plants upon which they had been feeding, crawl up the posts of the wire fence to the underside of the capping board, and change to mummy-like chrysalids, each securely fastened to the board by a silken pad at its hind end, and by a slender silken band about its middle. I found some of the chrysalids where I



Fig. 44—A Cabbage Butterfly Mummy or Chrysalis slung up to a rail.



Fig. 45.—Cabbage Butterfly. (a) Male, at rest, wings erect ; (b) female.

had seen them last fall ; but a few of these had been killed by the grubs of little four-winged flies that had stealthily placed eggs within the chrysalids before winter set in. The greater number had been snatched away during the winter by birds who had found out their hiding places.

If one of these chrysalids is brought into a room in early spring, it will not be long before another wonderful change takes place. It will first show slight signs of movement, then its skin will crack open along the back, and soon a white butterfly will come out. At first its body will be soft and weak, and its wings small and shriveled ; but in a few hours the body will become firm, and the wings will be filled

out and expanded, ready for flight. As soon as the March snows have melted, many of the white butterflies may be seen flying about, lured by the bright sunshine into leaving their comfortable winter-quarters for

the warm breezes of early spring. But if cold weather returns again many a poor butterfly is frozen to death. Those that have been made only stiff with cold, the sun's hot rays bring back to life again.

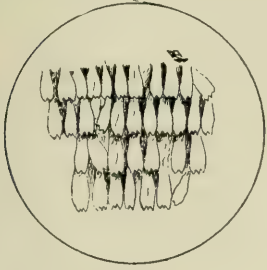


Fig. 46.—Scales on the wing of the Cabbage Butterfly. They overlap like shingles on a roof.

The nature student will observe that all the white Cabbage Butterflies are not marked exactly alike. Some have two black spots just below the middle of each fore-wing, while others have only one. The former are the females, and the latter the males (Fig. 45.) They all have six legs, and four wings covered with very small scales, which brush off

readily. Under a microscope these scales can be seen to have the shape and arrangement shown in Fig. 46.

But there are scale-winged insects which are not butterflies; for example, the large army of moths, big and little, which are readily attracted to lights during the late summer months. We can, however, easily tell butterflies from moths in these ways: The wings of butterflies at rest are held erect, while those of moths are folded closely over the back or by the sides; the feelers, or antennæ, of the butterflies are always knobbed at the tip, while those of moths are either simple or feathery; and butterflies fly about during the day, while moths as a rule fly at night or in the dusk. (Fig. 47.)

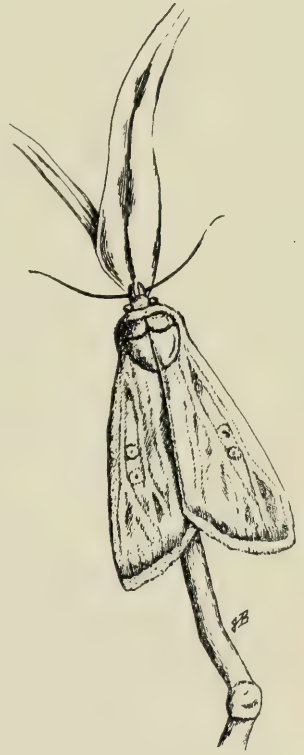


Fig. 47.—An Army-worm Moth at rest, showing the simple feelers, how the wings are folded.

Like most butterflies, the white Cabbage Butterflies are fond of sipping the honey of flowers; but, unlike many, they show no decided

liking for any special color or plant. Some observers are of the opinion that they perhaps visit yellowish-white flowers most frequently, but of this fact we are not absolutely certain. It is always interesting to creep up to a butterfly which is sipping nectar from a flower, and

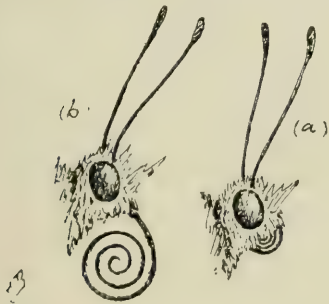


Fig. 48.—Head of Cabbage Butterfly, showing the sucking tubes coiled in (a) and partly uncoiled in (b).

watch it uncoil its long sucking tube and insert it into the corolla. The honey is sucked up through the tube by means of little muscles acting



Fig. 49.—The eggs of the Cabbage Butterfly.

on a bulb at its base, just as water is drawn up from a cup into the mouth through a straw. (Fig. 48).

The female Cabbage Butterflies begin laying their pale-yellow eggs about the middle of April on the leaves of Shepherd's Purse, Mustard, and other like plants that have already come up. These eggs are beautiful objects, flask-shaped and ribbed crosswise as well as up and down. We must, however, examine them under a microscope, if we wish to see their extremely delicate beauty. Usually several eggs are laid on the under surface of the leaves in an erect position, but seldom are they in clusters. (Fig. 49).

In about a week tiny green "worms," or caterpillars, hatch from the eggs and begin to nibble at the leaves provided for them by the instinct of the mother butterfly. They eat greedily, and "gorge themselves till they seem near bursting." As a result, their growth is rapid; but as the outer skin cannot stretch enough to allow for the increase in size, the caterpillar must at certain times form a new skin under the old one and throw off the latter. This *moulting*, as it is called, occurs four times in the life of the caterpillar, before it changes into a chrysalis.

How different these caterpillars look from the white butterflies!

They have horny biting jaws which work sideways, and eight pairs of legs—not all alike, however, for the last five pairs are more like stubs than legs. Their feelers can scarcely be seen, and wings are altogether wanting. Their bodies are long, and are plainly made up of thirteen segments, or rings.

Reference has already been made to the change from the caterpillar to the chrysalis. The first summer chrysalis stage lasts about twelve days, and a second brood of butterflies appears about the end of June. Eggs are again laid, from which a second brood of caterpillars makes its appearance and feeds on the leaves of cabbages and other allied plants during part of July and August. These change into the second summer chry-

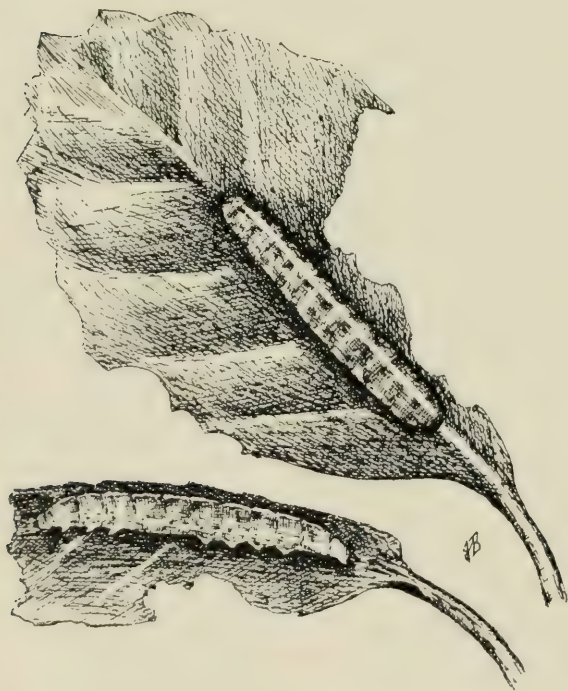


Fig. 50. Two full grown cabbage worms resting after a good meal.

salids, from which in twelve days the third brood of butterflies comes out in September. Eggs are again laid, and from these hatch the caterpillars which are usually so abundant in late autumn. These change into the chrysalids which pass the winter under fence-rails and other places.

Quite often in autumn many cabbage-worms appear bloated and sickly. They are sluggish and have no desire to eat. If some of the

worms be put into a box and taken home, where they can be easily watched, the cause of the sickness will soon be made out. Small white maggots bore their way out through the skin and settle upon the

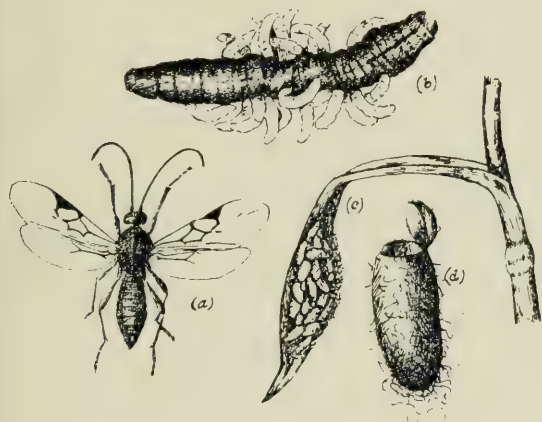


Fig. 51. (a) The 4-winged fly which lays her eggs within cabbage-worms; (b) the maggots coming out of cabbage-worm to spin their cocoons; (c) a mass of cocoons; (d) cocoon enlarged showing how the fly comes out by raising a lid.

poor caterpillar, as in Fig. 51; and if these maggots are watched, it will be found that they soon begin to spin silken cocoons about their bodies. The caterpillar has sometimes enough life left to crawl away from its tormentors an inch or two; but usually it dies beside them, and in a day or two no trace of its body can be found. If these cocoons be placed in a box for a few days, small four-winged flies will come out through lid-like openings at the end. These flies are *parasites*. By means of a needle on the hinder end of their body, they pierce the skin of the

cabbage worm and lay their eggs within its body; in a short time the eggs hatch small maggots, which grow and feed within the body of their host until they become full grown, when they come out as already described.

Frequently, too, some of the chrysalids, which we find in early spring, are dead and straw-colored. little, grayish maggots may be seen to fill up the entire space within; and, if the dead chrysalids are kept in a closed box for a short time, many little bronze-colored flies make their appearance. These flies also are parasites. Their eggs are always laid within the chrysalis case late in the fall, and the maggots which hatch from the eggs feed on the body of the chrysalid. In a short time they are full-grown, and fill up the space occupied by the body.

One other thing about this insect may be noted. Its breathing system is made up of tubes which branch through the body and supply air to the colorless blood. The openings of the tubes, or breathing pores, can be readily seen with the naked eye along each side of the body in the same line as the yellowish dots (Fig. 50.)

A good practical way of killing cabbage-worms, when they are spoiling the cabbages, is to dust a mixture of one pound of insect powder and



Fig. 52. The Insect and the Boy.

five pounds of flour through a cheesecloth bag upon the infested plants. The fine powder of the mixture fills the breathing pores, so that the air cannot get into the interior of the body, and the worm is suffocated

How strange and eventful is the life of this butterfly! *Strange*, because, beginning life as a beautiful egg, which is easily broken, it soon becomes a sixteen-legged worm-like creature, which, after growing and moulting, reaches a certain size; then it changes into a passive body resembling an Egyptian mummy; which after remaining in this state for a definite time, bursts its case, and comes out a dainty, white, four-winged insect, flitting hither and thither among the flowers and sipping their sweets. *Eventful*, because it is ever exposed to danger from the attacks of parasitic insects, birds, and other animals, including man himself, and from the changing conditions of heat and cold, rain, and snow.



Fig. 53. The story of a cabbage-butterfly for a year. There are three broods or generations.

THE STORY OF THE BEES.

H. R. ROWSOME.

Almost every one has, on some drowsy midsummer day, stood before a hive of bees, as close as he dare, and watched with absorbing interest the small portion of their daily toil he was able to see going on around the hive entrance, and has wondered what operations were carried on within that busy community.

If the hive is of a comparatively modern form—one with movable combs set within wooden frames - it is an easy and safe matter to open the hive, take out the combs, and watch its inmates by the hour. Bees do not know one person from another, except as one learns their whims in order to deal with them peaceably ; they are annoyed by persons standing in *front* of a hive and interfering with their flight to the hive. It is not well to wear woolly or black clothes when among bees, because the hereditary antipathy of bees to the bear is aroused if they catch their hooked feet in woolly clothes or hairy wrists ; bears, on their part, keep up their traditions by destroying many telegraph poles in searching for bees' nests, on account of the humming of the wires.

Place a veil of leno over your head, get a bee-keeper's smoker, and puff a few whiffs of smoke in at the entrance to the hive. This drives the sentinels, who are looking for robber bees, into the hive ; gently lift up the cover and blow half a dozen puffs over the tops of the frames. The smoke causes the bees to go down into the hive ; each one dips head first into a cell and fills herself with honey and is then as good natured as a man after a full dinner. Now with a screw-driver pry a frame loose and lift it out. On a warm day all the combs may be taken out and leaned against the hive. One should be careful not to make rapid movements as if inviting a fight, and should avoid crushing the bees or jarring the hive.

One will first notice that it is at the top of the combs that the honey is placed. This is for the sake of convenience in feeding the brood below, just as in a stable, the hay is stored in the loft. Honey, as such, does not exist in flowers but is really *made* by the bees. The bee has a very long under lip of reddish color, which can very readily be seen when in use ; and with this she laps up the nectar that is contained in flowers. This nectar passes into a sort of crop and there undergoes a chemical change, which gives it certain medicinal qualities that make it curative of colds. This is honey. The bee gathers a load of twice its own weight. One can easily notice how a loaded bee drops heavily upon the alighting board, almost with a thud, or, missing it, falls into the grass before the hive and pants and struggles for half an hour to reach the hive. Each bee fills one cell at a time. The honey, as it is carried into the hive, is nine-tenths water, most of which has to be removed or the honey will sour. The bees accomplish this, especially at night when they cannot work in the field, by standing in rows before the entrance of the hive ; and there, in rank after rank all along the bottom board and up on the combs, their heads all pointed towards the interior, with abdomens thrust

upwards and feet firmly planted, they go through the motion of flying without stirring from the spot. This forces a strong current of air through the hive, which absorbs the moisture in the honey and carries it outside of the hive. The work is very exhausting, and they work in short relays or shifts. In this way, if a colony has gathered a hundred pounds of honey in a season, it has also expelled from the hive one or two barrels of water. By this means too, the hive is ventilated and kept cool in very warm weather; but if the entrance is so very small that but little air can be forced in, the bees become discouraged and turn to loafing. The bee is not always an example of industry.

When nectar cannot be obtained bees will suck juice out of fruit. Raspberry juice will show through the bee's abdomen and give it a bright red appearance. Sometimes they gather a very rank liquid from the surface of leaves and grass. It looks like dew, and is called honey-dew. It falls upon the ground, being sprayed into the air by a louse or aphid, —the cow of the ant.

Looking at the comb again, you will notice that just below the honey there are many cells filled with a red or yellow substance. This is pollen, often called bee-bread, because it tastes not unlike bread. We used to believe that the legs of the bee were wax, or the dust of the anthers on the pollen brushes of ball and placed in the pollen basket with stiff hairs on one side. One can watch this operation very closely by placing, in a dish of oat meal thirty yards or so from the hive, with a little honey in it to attract bees there. Bees sting only in the immediate neighborhood of their hive. Sometimes when the pollen is very plentiful, as in cucumber blossoms, they roll their bodies in it and pick it off with their feet. Each bee visits only one kind

of flower on each excursion and thus the flowers visited are cross-fertilized without being hybridized. Another product that is carried in this way is bee-glue. It is used to stop up cracks in the hive to keep out draughts. It is that sticky substance on poplar and horse chestnut buds. Below the pollen is the greater part of the comb which is nearly black and contains the brood or young bees in all stages of growth.

FIG. 54.—B, Hind leg of worker; *e*, tibia hollowed on outer side as pollen-basket; *f*, tarsus with pollen-brushes; *g*, foot, with claws, side view; C, foot, front view, more enlarged. [From nature.]

The most important personage in the hive is the queen or mother-bee, — so-called because she is the mother of all the bees in the colony. She is shy and hard to find, but easily recognized, being nearly twice the size of a worker. Early in spring when food commences to be brought in—for the queen is provident and will not lay when the larder is empty—she begins to deposit eggs, one at the base of each cell, and slightly glues it

there. If she happens to place two or more eggs in a cell, the workers, that is the bees that sting, remove all but one to other cells.

Drone, or male, eggs are placed in the larger cells and workers or female eggs in the smaller cells. She lays eggs of either sex at will; and the workers can distinguish the sex of an egg by some unknown instinct. At the end of three or four days, the eggs hatch into small, white maggots. The nursing bees prepare a

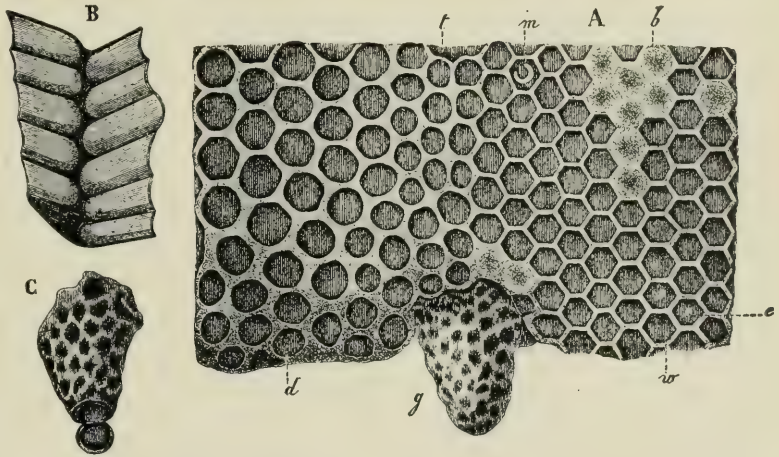


FIG. 55.—A, Comb, front view: *d*, drone-cells; *w*, worker-cells; *t*, transitional cells used for storing honey and bee-bread; *g*, queen's cell; *b*, brood capped over; *e*, eggs; *m*, larva or maggot. B, Section of sheet of comb, showing inclination of cell. C, Queen-cell, with cap cut off by workers. [From nature.]

food of honey, pollen, and water, partially digest it after the manner of patented foods for infants, and pour it into the cells for the grubs. In from four to six days, the maggot grows almost large enough to fill the cell. The nurses then seal over the apartment with a porous lid of wax and the grub enters the pupa state. From the middle part of the under lip two silky threads issue, which cling together and form a single thread; continually extending and retracting its body, it spins a silky white cocoon, something like that of the silk-worm. The inmate of the cell is now transformed into the shape of a bee, but is pure white, and for that reason is called a nymph. In twenty-one days or so after the egg is laid, the young bee chews away the cap of the cell. If you examine a comb of sealed brood, you will generally see two or three of them with their heads half way out of the cells, taking a first view of the world. When they emerge they are weak, flaccid, half grown creatures, covered with silver grey hairs that give them such a new appearance as to excite in the beholder the liveliest sympathy. The nurse bees then clean out the cell and fasten down its silken lining which serves to strengthen the comb, and is so thin that a hundred of them scarcely diminish the size of the cell. The first day the young bee does little but crawl about and sip honey; then in its turn it becomes a nurse and feeds the maggots. When about ten days old, along with scores of other young bees, it plays during the warm part of the day, just before the entrance to the hive. It is a pretty sight to see them dancing in the warm sunshine and learning the use of their wings; in half an hour they go into the hive again and all is quiet. Besides being nurses they are tidy little housekeepers, removing every impurity and all dead bees. At two weeks, the young bee builds comb and goes for its first load of pollen, of which it is as proud as a boy is of his first pair of trousers. After this it undertakes to gather nectar. After from two to four

weeks of this labor, it dies from the wear and tear of life. This generally happens out in the field, when, under a full load of honey, it is too feeble to reach home ; or its career may be cut short by the toad that lives under the hive, or by the kingbird, or its feet may be stuck fast in the gummy pollen of the milkweed. But in winter and spring they live eight or nine months.

The drone or male eggs are laid in cells a third larger than the worker cells and, when capped over, are much longer. The drones are bulky and have the proportions and habits of the alderman of tradition. They fly about in the middle of the day to sharpen their appetites, and when in the hive, do little but gobble and sip honey. They can neither sting nor collect food. However, when food does not come in rapidly, they are bundled out of the hive ; often a wing is torn off and they are given a hint to go. This happens every fall and, at that time, the drones will be found all by themselves on the outside combs, hiding from their termagant sisters, after the manner of men in house-cleaning time. When expelled, they are often found in some warm place like a hot-house.



Fig. 56.--The queen and her retinue.

The queen, curiously enough, is hatched from a worker egg, and is often developed from a worker maggot. When bees wish to rear a new queen, they choose three adjacent worker cells, cut out the partition walls, and throw them into one. The cell is turned downward and looks very much like a peanut. Two of the worker maggots are destroyed and the third is supplied with about half a thimblefull of very strong food, called royal jelly. The worker grub, two or three days old, is to be changed into a queen. Sometimes when worker eggs or maggots cannot be found, bees will, without giving up hope, try to rear one from a drone grub, which, however, dies from the strong food. Two days feeding on this food, alters her color, curves her sting, doubles her size, deprives her of wax pockets, lengthens her life to three or four years, and reverses all her instincts. When she leaves the cell in which she has lain head downwards, she takes a sip from an uncapped cell ; and then runs around and stretches her legs. She hunts for other queen cells of which there are about a dozen. If the workers permit her, she tears a hole in the side of the cell and stings the inmates because queens will not tolerate a rival. If another queen is found they fight, the workers standing around, and not interfering. Queens very often are afraid to leave their cells ; and in that case they pipe—making a plaintive cry, a sort of “peep, peep,” that may be heard several yards from the hive.

If nectar and pollen are coming in in large quantities, the queen will sometimes lay two or three thousand eggs a day, producing during her lifetime between a million and a million and a half. The hive, of course, becomes overstocked by the amazing fertility of the queen ;

and steps are taken towards sending out a colony. Queen cells are begun and a week before the first queen comes out, by a sort of preconcerted mutual agreement, the inmates of the hive divide into two parties, one remaining in the hive and the other, which consists of the old queen and about three quarters of the colony, starts out to seek fortune elsewhere. Besides the old queen, the swarm is composed of many young bees, some of whom fall upon the ground too feeble to fly, drones, and a number of veterans whose tattered wings and hairless bodies show that they have seen something of life. The departing queen soon settles on the branch of a tree or other convenient spot and the whole swarm collects in one solid mass around her. While the swarm hangs there, scouts are sent out to look for a suitable home, and a hollow tree in the woods is generally chosen. In Asia Minor, a treeless country, swarms were sometimes found in the stomachs of dead beasts, as in the case of the lion killed by Samson ; and from this arose the superstition* that decaying flesh could of itself produce a colony of bees. The scouts return and report, for one bee may often be seen talking with another by crossing its horns, or antennae, with its own. The cluster of bees breaks up and follow the scouts. Even in these days some try to make a swarm cluster by tanning or beating tin cans. This is a survival of a heathen ceremony. The worship of the goddess Cybele, who taught mankind agriculture, was enthusiastic. Her priests ran about with dreadful cries and howling, beating on timbrels, clashing cymbals, sounding pipes, and cutting their flesh with knives. There is another tradition. If there has been a death in the family, the bees will take offence and die during winter, if they are not informed of the event.

Bees had a government and a civilization when we were savages. The division of labor was understood ; laws of hygiene were practiced ; and provision for the rainy day was made, when our ancestors obtained their daily bread by turning over stones in the pools of the sea shore, looking for crabs and clams.

* Compare the legends of Aristæus the first bee-keeper.

THE STORY OF THE BIRDS.

PROFESSOR M. W. DOHERTY.



HE snow has gone, the grass is growing green again, the buds are swelling in the trees, the leaves begin to open - Spring has come ; and, in a few days, we may expect to see our feathered friends again. They have been paying a visit to the people of the South, and, having travelled in foreign places and seen strange sights, they will greet us on their return with a merry tale set to sweetest music.



Fig. 57. Swallows migrating.

Many kinds of birds spend the summer with us, and in autumn go southward to spend the winter months. Others come to us from the northern districts and remain here over winter, returning in the spring to the place whence they came. There are other birds that spend the winter season south of us and the summer season to the north of us, so that in their migratory flight, they simply pass through our district on the way to and from their breeding places. These are "passing migrants" A few remain with us summer and winter. Who has not heard the peculiar "quank, quank" of the White-breasted Nuthatch coming from the almost lifeless snow-clad woods. In spring and summer these same birds may be seen running up and down and around the trunk and limbs of the trees. As climbers, the Nuthatches excel. They can run rapidly



Fig. 58. The Cuckoo migrating.

down the trunk of a tree headforemost. Woodpeckers even do not attempt this feat. In the southern part of the Province, the Crow remains all winter ; and so, along with the Nuthatch, must be classed as a "resident."

The migratory flight of birds is a most interesting study, and has engaged the attention of bird-lovers for centuries. A great deal, however, is not yet understood regarding the "lines of flight." For instance, "The Eastern and Western Movement of the Blue-bird" in our Province remains unexplained.

What causes these migratory flights ? You immediately answer : "The change in temperature." This answer is partially correct, but you are leaving out of consideration a very important factor, viz., *food*

supply. This, coupled with inherited memory, probably more than anything else, controls the migration of birds. Do all birds migrate in the same

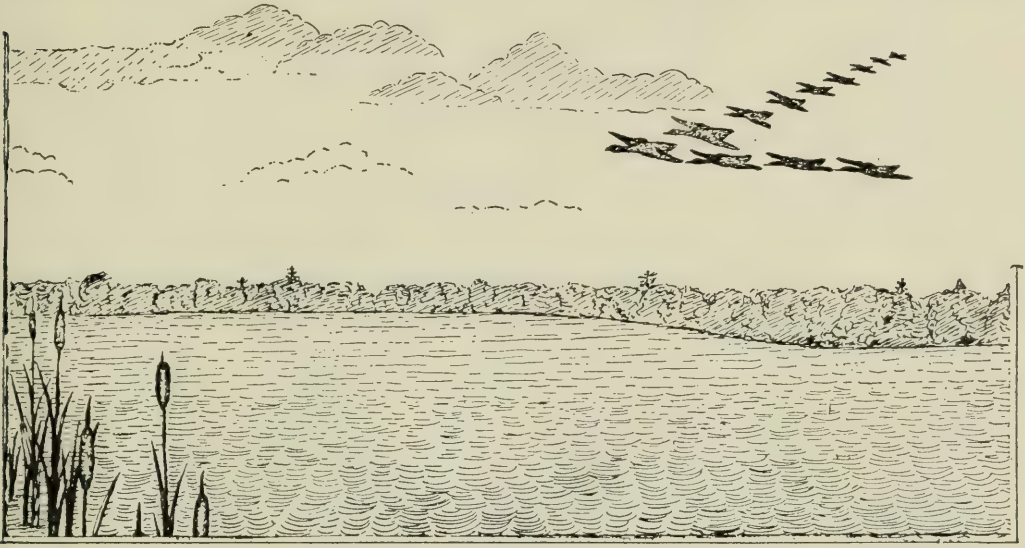


Fig. 59. The flight of the ducks.

manner? No. We have all seen Swallows gather together in immense flocks before leaving us. There are others again, such as the Cuckoo,

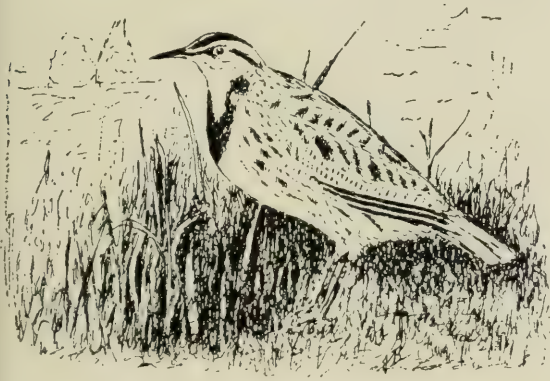


Fig. 60. The Meadow Lark.

which quietly steal away in pairs, or in very small flocks. Some birds in their flight remain close to the earth, while others fly at such a height that they remain unseen to the naked eye. Some move mostly at night, others in the daytime. Some birds migrate to the south, leaving their young

to follow them at a later date. In most cases the males precede the females by some days in their return to us in the spring.

Before the snow is gone, we may hear the shrill piping notes of the Horned Lark coming from the plowed fields and meadows. The sound is not altogether unlike the pleasant note of the Meadow Lark. Early in March, the sharp-eyed, cunning old Crow bids good-bye to the southern parts of the Province and moves northward, with his head filled with new



Fig. 61. The return of the Crows.

schemes whereby he hopes to grow fat and to render the farmer helpless to prevent his devastations of the fruit trees and corn fields. Then follows the Robin, whistling and strutting around with renewed vigor and grace. Then follow in rapid succession, Blue-birds, Song-sparrows, Black-birds, Phœbes, and a host of others, until the air is filled with music. Every tree, shrub, and meadow has its full orchestra.



Fig. 62. Taking Notes.

Every boy and girl should keep a record of the dates when the first of every kind of bird is seen each season. It will add greatly to the pleasure of spring-time.

NESTING HABITS. Of all the evil traits which have been handed down to man, none is worse than the predisposition of the bad "small boy" to rob birds' nests. How much nicer it would make the home, if instead of driving the birds away in disgust, the boys would all fix up some nesting

boxes in the old orchard, and upon the roof of the wood-shed. These need not be large nor expensive, and yet you will be astonished how soon the birds will use them as homes. Let every boy vie with his fellows to have the greatest number of birds summer around his home.

Here is a suggestion for you. Nail up some nesting boxes near your home, near by place some bits of string and hair that the birds may use in building nests. Then, if there is no water close by, set up on a post a tin dish that will catch the rain, and you can from time to time fill it with fresh water. This drinking place will attract the birds. Now keep track of the birds that come around, and, if you do not frighten them away, you will soon have some birds coming regularly to make their home with you. These new friends will be interesting, and you will be much happier in watching them coming and going through the summer than in frightening them away.



Fig. 63. Happy Homes.

Many of the birds are paired before they reach us in the spring, and soon they are busy making snug little homes in some secure and sheltered spot. The little workers labor industriously, all the while giving

forth sweet melody. Birds differ widely in choice of places for their nests. The Horned Lark is satisfied with a shallow hollow in a meadow; while the Baltimore Oriole, trim of figure and bright of color, suspends its bag-like home from the end of some drooping bough, very frequently overhanging a stream (Fig. 64). The Bluebird prefers a hollow post or



Fig. 64. The Oriole's Nest.

fence-rail; the Bank Swallow, a home made in a sand bank; and the Blue Heron, or Crane, as it is erroneously called, selects the lofty top of a tamarack or black ash wherein to build his home of sticks.

Watch carefully during the summer, and make a list of the birds which build their nests: *1st*, on the ground; *2nd*, in shrubs or trees not more than 15 feet from the ground; *3rd*, in trees at a greater distance than 15 feet from the ground; *4th*, in other places, as sand banks, eaves of buildings, chimneys, etc.

MAN AND BIRDS. From an economical, as well as an aesthetical, standpoint, man should always be found offering protection to birds. This statement is made with full knowledge of the fact that there are a few members of this class of animals which are of little service to us, and are not distinguished for their beauty.

Nevertheless, the fact remains that, as a class, we should offer them every protection, cultivate their acquaintance, and encourage them to build nests and remain with us. It is very doubtful, indeed, if there is a single species of bird for the total destruction of which we would be better off. Those who dispute this point have never made a careful study of the



Fig. 65. The Bluebird's Nest.



Fig. 66. Woodpeckers at work.

feeding habits of birds. Many unthinking persons condemn Woodpeckers, which are seen flying to and fro in the orchard, because it is

assumed that they are working injury. A careful field study of their food habits, and an examination of the stomach contents, would reveal the fact that these birds are destroying thousands upon thousands of injurious insects, particularly those which burrow in the wood. The orchardist sees the Robins carrying off a few of his cherries, and immediately some thoughtless boy brings out the shotgun, with the result that dozens of these hard working friends are destroyed. In all probability, had it not been for these birds, there would have been no cherries ; insects would have completely destroyed the foliage and fruit.

Definite information regarding the food habits of birds can be obtained only as a result of careful study and field observations, together with the examination of a large number of stomachs. A study along these lines frequently results in a complete change in our attitude towards the species under investigation. For instance, in the case of the Downy Woodpecker, an examination of a large number of stomachs revealed the fact that 13 per cent. of the food consumed, consisted of wood-boring beetles, 16 per cent. of bugs that live on the fruit and foliage, and a large proportion of the remainder is made up of scale insects, ants, and other such insects.

We might thus speak of all our common birds, and show that most of them are entirely beneficial ; and, as to the rest, their depredations are very small when compared with the beneficial service which they render to the gardner and orchardist. Farmers each year spend much time and money in keeping up the fight with aggressive and persistent weeds. Seldom do they realize that their efforts would be of little avail, were it not for the many varieties of birds which each year destroy millions upon millions of weed-seeds.

Birds have enormous appetites, and, as digestion is rapid, a large quantity of food is consumed each year. They eat during three hundred and sixty-five days of the year, so that, even though they do treat themselves to an occasional feed of luscious fruit, during two weeks of the year, we may rest assured that during the other fifty weeks they are with us they have rendered us services valuable far beyond the injury.

If the birds were destroyed, it is very doubtful whether after ten years a farmer or gardener could possibly bring any crop to maturity.

THE STORY OF AN APPLE.

PROFESSOR H. L. HUTT.

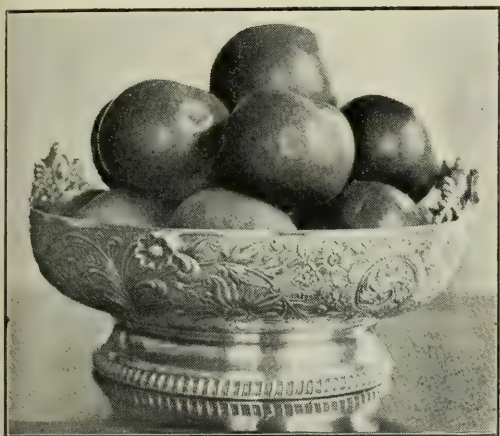


FIG. 67.—McIntosh Apples.

One evening after tea, I had just settled down in my easy chair for a glance at the newspaper, when my trio of little folk pounced on me for a story. "A fairy story," said Jean. "No, one about wild animals," said Fred. "I like to hear about what you did when you were a little boy," said Gordon. Here was too much of a variety to be given all at once; so I said, "Look at those beautiful red apples on the table." "Wouldn't you like to hear their story?" Fred was doubtful whether much of a story could be told just about apples;

but I informed him that every apple has a history, and some have a very interesting one. "What variety of apple is that?" I asked. "A McIntosh," they all shouted in chorus, for they had been learning the names of apples, and were always pleased to be able to identify a variety correctly. "How do you suppose it got that name?" I next enquired; but as this was too much for them, I said, "Well, that is where we will begin our story.

"Once upon a time (for all good stories begin that way), about thirty years ago, on a farm near Dundela, a little village in Dundas County, in the St. Lawrence Valley, lived a man by the name of Allan McIntosh. He was one of the early settlers in that section, and had cleared off most of the forest which once covered his fields, only a few acres of it having been left for bush. The bush was the favorite resort of the cows when the weather became warm and the flies were too troublesome in the adjoining pasture field.

"One evening, late in September, when Mr. McIntosh's little boys, Allen and Harvey, were hunting through the bush for the cows, they espied just on the edge of a clearing, a little tree bearing near its top a number of bright red apples. If they had discovered it sooner, they might have found many more on the lower branches. What do you suppose had become of them?" "The cows must have got them," suggested Fred. "Yes, the cows had found them first; but the boys were soon up the tree making sure that the cows would get no more of them.

"The apples were at that time hardly mellow enough for eating, but that did not prevent the boys from sampling them; and they declared that they were the finest wild apples they had ever tasted. Those not eaten at once were taken home and kept in the cellar till the family gathering at Christmas, when all present pronounced them finer than any of the named varieties grown in the little orchard near the house.

"Here then was a little tree growing wild without any care given it, yet it produced handsome apples of fine quality. How do you suppose it came to be growing there?" "Somebody must have planted it," declared Gordon. "No," I said "it was not planted, but grew there from the seed, and was, therefore, what is called a chance seedling." "The Brownies must have planted it," remarked Jean. "Well, probably they did," I said, "but I think the Brownies in this case were the men who helped to chop down the trees in the woods; for it is most likely that they had taken with them some Snow apples to eat when they felt hungry. They threw away the cores and when these rotted the seeds were left on the ground, and from one of these seeds this little tree may have grown."

"What makes you think they were Snow apples," inquired Jean. "Well," I said, "if you will fetch a few Snow apples from the cellar, to compare with those in the dish, you will probably find the reason yourself." In less time than it takes to tell, they were making comparisons, and they agreed that there was not much difference in appearance, except that the McIntoshes were, on the whole, a little larger and redder than the Snows. "What makes those black spots on the skin," asked Gordon, "they are on both kinds." "Those," I replied, "are caused by a fungous disease with which the Snow apple and its relatives are often troubled. Now cut an apple of each kind and compare the flesh." "Why, they are both nearly as white as snow, aren't they?" asked Jean. "That is still further proof," I said, "that they belong to the same family. Now taste them." After much tasting of one and the other, it was decided that they were both so good that it was hard to say which was the better; but when asked to shut their eyes and guess the name of the one they were given to taste, they found no difficulty in telling which was the McIntosh, because it had a "spicy flavor."

"Now," I said, "I think that you have sufficient proof that these two apples are related. In fact, there is little doubt that the McIntosh, and a number of other varieties I might mention, are seedlings from the Snow, or, as it is more properly called, the *Fameuse*. None of these varieties, however, take their names from their parent. The McIntosh, as you may have already guessed, received its name from the man on whose farm the first tree of that kind was found."

"But how does it come there are so many trees of that kind now?" asked Fred. "We have them, and Grandpa has them, and lots of people have them." Well," I said, "that is one of the interesting points in the story of nearly all cultivated fruit trees."

"All of the McIntosh trees now growing in all parts of the country have descended from that one little tree in Dundas County, not by planting seed from it, for that most likely would have produced other varieties, but by grafting and budding other trees with cuttings and buds taken from it."

"One of the remarkable things about nearly all our cultivated fruit trees is, that trees grown from their seed show endless variations. If, for instance, you should plant 100 McIntosh apple seeds, probably no two of the trees from them would bear apples just alike, and most likely none of

them would bear as good fruit as the McIntosh, although it is just possible that even better fruit might be produced. Some day you may find this an interesting thing to investigate."



Fig. 68. A glimpse in the nursery.

"But what do you mean by budding and grafting?" inquired Fred. "These," I replied, "are methods adopted by nurserymen who make a business of growing trees, whereby they can grow any number of trees that will bear the same kind of fruit, without varying, as they naturally would if the trees were grown from seed. These methods of propagating trees depend upon the fact that every perfect bud on a tree is capable, under favorable conditions, of producing another branch; or indeed, a whole tree of the same kind as that on which it grew.

"The McIntosh in our garden is a budded tree, which was obtained from Mr. Smith's nursery, where he grows thousands of other trees just like it. In growing these trees, Mr. Smith had in long rows in the nursery, thousands of little seedling apple trees (that is, little trees grown from apple seeds), which, if allowed to grow naturally would, he knew, bear a great variety of mostly inferior fruit, but he had heard of the excellence of the McIntosh apple, and intended to make them all bear McIntosh apples; so he wrote to Mr. McIntosh and got him to send all the young shoots he could spare from his McIntosh tree. From these shoots, which were obtained in July, Mr. Smith's men budded the little seedling trees in the nursery rows. The bark on each little tree was cut open near the ground, and one McIntosh bud was put in and bound firmly in place.



Fig. 69. Budding the seedlings.

By the end of the season, the bud showed by its plumpness that it had been adopted and nourished by its foster parent, and to all appearances it was much the same as any of the other buds, except for the scar around it showing where it had been inserted.

"Early next spring, however, each seedling tree was cut off just above the McIntosh bud, which was thus suddenly given the responsibility of making a new top for the tree, and that is just what each little McIntosh bud did. In three years, each had made a little tree, big enough to be sold for transplanting; and that year they were all taken up and sent to the purchasers throughout the country."

"In Grandpa's orchard you may have noticed that the tree which bears the McIntosh apples bears also a few yellow apples." "Yes, Talman Sweets", said Gordon. "Well, that tree once bore all Talmans; but one spring Grandpa cut off most of its branches and grafted into the stubs left a few scions, or bits of twigs, from a McIntosh tree. These scions united with the growing part of the Talman tree, and produced large branches which bear the McIntosh apples, while the branches which were not grafted still bear Talman Sweet apples."

"By grafting into a large bearing tree in this way, Grandpa's tree was bearing McIntosh apples in three or four years; whereas our tree, being a young one, was nearly twice that old before it had apples on it."

"From the story of this particular apple, you will have learned how new varieties of fruits sometimes originate. Varieties found in this way



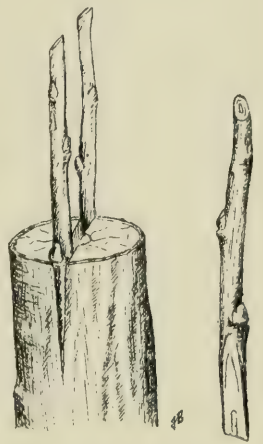
No. 70. The adopted bud with scar around it.



No. 71. Taken from the nursery and bundled for shipping.



No. 72. Old enough to begin bearing.



No. 73. How the grafting was done.

are said to be of chance origin. All varieties, however, do not originate by chance. Some are the result of careful and patient work on the part of men who not only gather and plant the seed, but contrive to have the new kind combine the good qualities of the two other varieties. If you will remind me of it next spring, when the trees are in bloom, I will show you how this may be done."

“ From what has been said about budding and grafting you will also have learned how a new variety, once obtained, may be multiplied and scattered all over the country. If you would like to try what you can do at such work, you may begin next spring by planting a row of apple seeds in the garden; and when the little trees are big enough, I'll show you how to bud them, or how they may be made to bear fruit in two or three years by grafting them into a bearing tree. How many of you would like to try it?” “I, I, I,” they all shouted; so we began operations at once by eating all the apples in the dish, to get the seeds for next spring's planting.



Fig. 74. Mr. McIntosh of Dundela and the original McIntosh tree.

THE STORY OF SUGAR.

PROFESSOR W. P. GAMBLE.

From early childhood, the boys and girls of Canada are familiar with the substance called sugar. We all know that it is used in large quantities for the purpose of giving a pleasant taste to many of the delicious dishes prepared for our use ; but how many of my young friends have taken the trouble to inquire into the origin and manufacture of this useful substance ?



Fig. 75. The Maple in summer.

There are many kinds of sugar ; but the one we shall speak of more particularly is the cane-sugar, so called because it was first manufactured from the sugar cane. Pure cane-sugar, as it appears on our market, consists of a mass of white crystals. If this sugar be heated to 320° Fahrenheit, it will melt to a colorless liquid, which rapidly assumes an amber hue, such as you have noticed when boiling it for the purpose of making taffy. If heated to a still higher degree, it turns brown, becomes less sweet, and gradually takes on a bitter taste.

Old-fashioned brown sugar owed its color and flavor, in part at least, to this treatment ; for, as sugar was formerly made, in the process of evaporation over the open fire some of the sugar was browned or half burned. Cane-sugar was formerly sold more extensively than at present in the form of coarse brown sugar. To-day, with the improved methods of manufac-



Fig. 76. The Maple leaf and key.



Fig. 77. The Maple when it bleeds.



Fig. 78. Shows a branch of the Maple when growth again becomes active.

ture, we see very little cane-sugar placed on our markets in this form. You might think that cane-sugar, from its name, is found only in

the juice of the cane, but not so. It is found also in Sorghum, a plant native to India, and now cultivated in the United States and in the south western counties of Ontario, near Lake Erie ; in certain palms, such as the cocoanut, and the wild-date palm ; in some kinds of grasses ; in the green stalks of corn ; in the Maple ; and in quite large quantities in the sugar beet. Maple sugar, on account of its unique and agreeable flavor, is now eaten chiefly as a luxury. This sugar, when freed from the color and flavor derived from the Maple, is identical in composition with that derived from the sugar cane. Most boys and girls in Ontario, especially those who live in the country, are familiar with the Maple, and the process by which sugar is obtained from it ; but why the sap runs from the Maple is not so well understood by the majority.

During the summer, the Maple is clothed with green leaves, which, through small openings on their underside, give off the excess of moisture taken up by the roots. Before the water is given off, the food which is held in solution is removed from it. This food goes to form a new growth of wood in the tree. In the autumn, the leaves of the Maple fall ; and through the winter, the tree stands bare and does not grow. In spring, if the Maple is bruised or cut in any way, we notice that the tree "bleeds," or, in other words, "the sap runs." We have also noticed that the "bleeding" of the Maple occurs at different times of the year. The sap will run from the Maple before growth has begun, and just as it is beginning. In the two cases, the cause of the run of sap is quite different. We find a good example of both kinds of bleeding in the gathering of sap by the sugar maker. Sap is first gathered when the ground is still frozen, and the roots are therefore almost, or quite, unable to absorb any water ; but, at the same time, the air is warmed through the middle of the day by the increased heat of the sun. At this season, the flowing of the sap from holes or cuts made in the trunk of the Maple is due to the expansion by heat of the air inside the smaller branches and twigs of the tree. This sets up at

once a pressure upon the sap, and this pressure extends to all parts of the tree. The sap with which the Maple is filled, is thereby forced out as soon as an opening is made for its escape. Later in the season, as the frost disappears, the roots begin to absorb water. This absorption process sets up a pressure within the tree, by reason of which

the water is forced out of the same opening. "Bleeding," or the flow of sap, from this last mentioned cause, continues until the leaves are sufficiently expanded to throw off the water absorbed by the roots. The other source from which we in Canada obtain cane-sugar, is the



Fig. 79. Keys of the Maple separate. During germination a radicle is sent out which endeavors to obtain a hold in the soil.

sugar beet ; and, because of the particular attention which it is receiving just now in many parts of our Province, we shall study it with a view to finding out its life-story.

Beginning with the seed, we find that what is commonly called the seed is in reality a pod. With the aid of a sharp knife, let us open a number of these pods, by cutting them straight across the centre. We now notice that the pod is composed of a rough irregular shell. Inside the shell are chambers, separated from one another by woody partitions. In some of these pods, we find but one chamber ; in others, there are as many as four or five of these cavities. Inside each chamber, we find the true seed of the beet. The seed, you will notice, is kidney-shaped. It

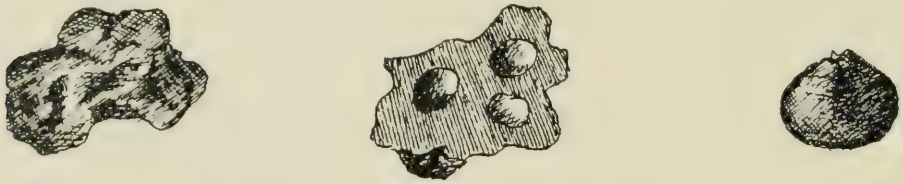


Fig. 80. The beet pod (on the left). The beet pod opened, showing the chambers within. The true seed of the beet (on the right).

is about the size of a turnip seed, and is enclosed within a dark brown wrapper. When this wrapper is removed, we discover the embryo, or infant plant, curved around a mealy substance. This mealy substance is the *endosperm*, and is the food upon which the young plant feeds during the germinating, or infant, stage. The embryo is the essential and most important part of the seed. It has root, stem, and leaves, although these organs are often as undeveloped in form as they are in size.

Boys and girls will do well to observe carefully the various stages in the act of germination. For this purpose, a dozen pods or more are sown in a soil kept duly warm and moist, and one or two pods are uncovered and dissected at successive intervals of, say, 12 hours, until the process is complete. In this way, it is easy for us to trace all the visible changes which occur as the embryo starts to grow.

We thus notice that the seed first absorbs a large amount of moisture. As a result, it swells and becomes soft. The embryo enlarges, and shortly the shell bursts, and a sprout makes its appearance. In the figure given below, you will notice three sprouts making their exit from a single pod. Notice also that these sprouts have the same general appearance. Each sprout is called a radicle. In time, the radicle becomes the true root.



Fig. 81. A beet pod showing three sprouting seeds (on the right). The radicle making its exit from the seed coat (on the left).

In the process of germination, the young plant grows at first wholly at the expense of the seed. It may,

therefore, be compared to the suckling animal, which, when newly born, is unable to provide its own nourishment, and consequently depends

upon the milk of its mother. The *cotyledons*, or young leaves of the plant, during germination absorb the endosperm, and remain within the seed coat some time after the radicle has made its exit. When the plantlet ceases to derive nourishment from the mother seed, the germinating process is finished.

The baby stage in the life-story of the young plant is passed. It must now depend on its own exertion to supply the necessities of life. For this purpose, the radicle buries itself in the soil, and sends out slender rootlets to gather in the food found there.

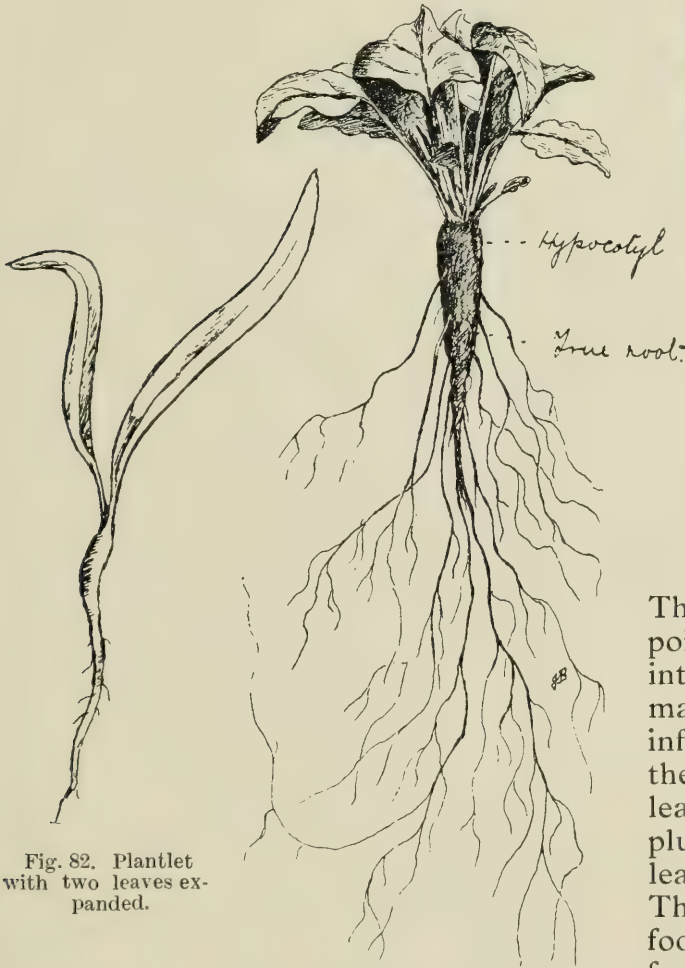


Fig. 82. Plantlet with two leaves expanded.

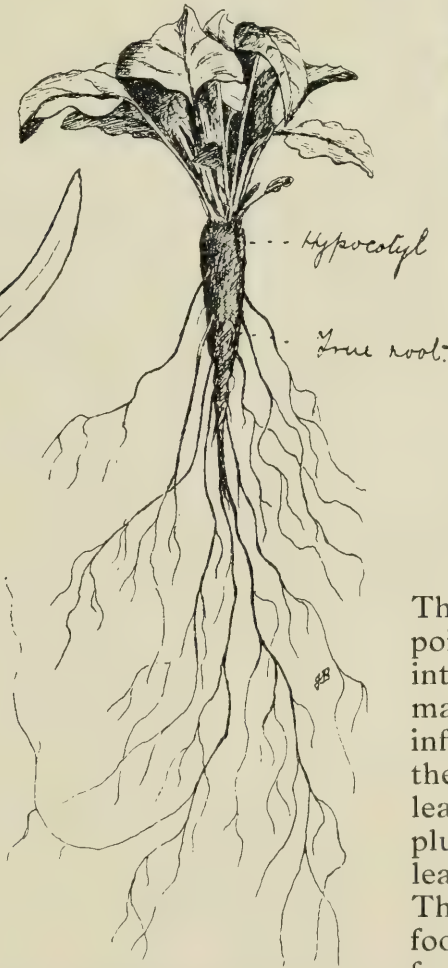


Fig. 83. Showing immense development of the root system of the beet.



Fig. 84. Sugar Beet at full growth.

The *plumule*, or growing point of the embryo, ascends into the air, in order that it may come under the direct influence of the sunlight. As the days pass, we notice new leaves unfolding from the plumule. Why are these leaves sent forth by the plant? The leaves, like the root, are food gatherers. They absorb from the atmosphere substances which are necessary to the formation of plant

food, and it is in the leaves that the manufacture or working over of those materials obtained from the soil and from the air takes place.

Let us now direct our attention to the root of the beet. Removing the earth carefully, we find that there is one well developed root pushing straight downward into the soil, and that smaller roots are sent out from it in two side rows. We notice also that for some distance below the surface of the soil the main root is smooth, and free from these smaller rootlets. How is it that so very little of the fleshy root of the beet appears above the surface of the soil? In reply to this question, we would ask you to observe the great length of these rootlets. "It has been frequently found that drains four and five feet below the surface of the soil have been blocked by them." As the rootlets develop, therefore, they exert a downward force upon the bulb, and this force tends to draw the bulb into the soil.

Conditions being favorable, the beet plant grows quickly. The main root thickens rapidly for a time; then we observe a less marked increase in size, and finally we can detect little, if any, development in this direction. During its development, small sacs, or cells, are formed within the root. These cells act as store-houses for the food material of the plant.

Let us again observe the leaves. The first thing that attracts our attention is the color of the leaf. Have you ever thought of the cause of

this shade in the leaves of growing plants? It is due to the presence of a certain green substance known as *chlorophyll*. This big word has been made up from two Greek words that simply mean "leaf green." This chlorophyll plays a very important part in the life-story of sugar. The particular use of this green matter is to change the raw material into plant food. One of the chief materials of plant food is carbonic acid gas. This gas comes from the lungs of animals. All living creatures are continually breathing out carbonic acid from their lungs. This gas is poisonous to



Fig. 85.—Shows the stem sent up from the crown of the beet. Second year of growth. The flower of the beet (in upper corner on right.) The ovary cut down through the centre (in lower corner in right.)

man, but is an essential food of plants. Without this food, the plant could store up no sugar, nor could it even live.

Carbonic acid gas passes into the leaves of the plant through small openings situated on the underside of the leaves. Large quantities of this gas are taken in by the leaves of the beet plant. This gas under the influence of chlorophyll is made to unite with water, and thus form a compound from which sugar is ultimately derived. After the sugar has

been formed in the leaves, it is carried to the roots of the beet by the downward flow of the sap or juice. In the root of the beet, the sugar is deposited in cells, which very closely resemble those of the honey-comb in structure.

You will naturally ask : Does the beet go to all the trouble of manufacturing and storing up sugar for our special benefit ? Not at all. As you all know, the sugar beet does not produce seed during the first year of its growth. If we take a beet root from the cellar and plant it we observe that it again begins to grow. From the crown of the beet, a strong leafy angular stem is sent up. This stem bears the flowers which are the forerunners of the fruit. The flowers, you will notice, are arranged at short intervals along the stem and its branches, and are usually in clusters of four or five. Below each cluster is a small bract.

The flower possesses a perianth, which is composed of five small green leaves. The lower part of the perianth is united with a fleshy substance called the receptacle. We also notice five stamens opposite the perianth. The ovary, or sac, encloses a small body called the ovule. The ovule eventually changes into a seed or fruit.

After fertilization, the receptacle and base of the perianth of each flower enlarge considerably. In this way, the perianth of each flower becomes more or less firmly attached to each other. The fleshy portions, with the ovaries, eventually become hard. These spurious fruits finally come into the market as "seeds."

During the period of growth and development of the fruit, what has become of the bulb or fleshy root ? Upon examination, we find that only the walls of the former bulb remain (Notice Figs. 84 and 85). What is the cause of this change ? The reply is : The store-house has become emptied of its contents. By what agency ? The sap or juice has carried it up for the young seeds in the course of their development. We see therefore, that the sugar and other contents of the cells in the roots were stored up by the plant for the purpose of supplying the food necessary to fruit or seed, production. In obtaining sugar from the beet, we, therefore, simply intercept Nature's plans, and are thus able to appropriate that which was not originally intended for us. This sugar is stored up by the beet plant in the root that it may feed itself the next season when it is forming seed.

We shall now examine the process of the manufacture of sugar from the beet. The beets are at the close of the first season removed from the soil, and are taken to the factory. At the factory, they are put into large sheds with V-shaped bottoms, which are connected with the factory by means of channels. Through these channels a moderate flow of water carries the beets into the first washing machine. By means of a spiral arrangement, the beets are tumbled about, washed, and carried along until they drop into an elevator. This elevator carries the beets to the top of the building, where they are weighed and sliced in such a manner as to open up the cells of the beet as much as possible.

We have already noticed that the cells of the beet in which the sugar is deposited are very similar to those of the honey-comb. Therefore, it is very important that the knives used in the slicing operation be sharp, so

that the cells may not be ruptured, but clean-cut. As the slices come from under the cutter, they are put into large tanks. Warm water is forced through the contents of these tanks or jars. By the action of the water, the greater part of the sugar contained in the sliced beets is dissolved. You know how quickly sugar will dissolve in water. The water containing the sugar in solution is then withdrawn from the tanks and taken to a measuring tank. The part of the sugar beet left over, that from which the sugar has been extracted, is called "pulp." This pulp is of no further use in the manufacture of the sugar, and is therefore thrown aside or taken to feed stock.

After the liquid containing the sugar has been measured, it goes to the mixer, where it is mixed with lime, and then put into a large tank for carbonation. Carbonation is the process of converting the lime and other impurities in the mixture into an insoluble form, by means of carbonic acid gas forced through the bottom of the tank. The mixture is then poured into a filter-press. A filter-press is simply a large strainer, by means of which the insoluble matter is retained, as the clear sugar solution goes through. This process is repeated a second time, after which the solution is treated with sulphur fumes. The syrup is then boiled down to remove the water contained in it. This is done by passing the syrup through four large boilers. What is left after the boiling is called thick juice. This juice is again boiled in a peculiar kind of pan, called a vacuum pan, and now becomes raw sugar. The raw sugar is then run into centrifugals, which are machines used for the purpose of separating the white sugar from the molasses. At this stage, the sugar is, of course, damp. By means of a granulator, this wet mass, which has the appearance of snow, is dried. It is then run through sieves to separate it into fine and coarse grained sugar, and is ready for the market, clean, white, crystalline sugar, such as we use every day on the table. Some of the sugar that we use has been made from sugar cane grown in the West Indies or in South America, some has been made from sugar beets grown in France and Germany and Belgium. We cannot tell the difference between the two kinds—there is none. We shall soon be using sugar that has been grown in beets by the farmers of our own Province.

THE STORY OF AN EGG.

W. R. GRAHAM, B.S.A.

Everyone is familiar with the size and shape of an egg; but very few of us stop to think how wonderfully it is made. We all know that the contents of the egg are enclosed in a shell. This shell appears to be hard and solid, but this is not the case. True, it has much strength; but we find upon examination, that it is full of little holes. These small holes allow the air next to the shell to get into the egg. Thus it will be seen that we should keep the egg in a clean place, away from dirty straw, such as we often see in the nest; also away from strong-smelling substances, such as onions; otherwise, these strong odors, passing through the shell, will affect the taste of the egg more or less.

Next to the shell is a thin tissue. This tissue is made of two layers all over the egg, except at the large end, where they separate, forming a small open space, called the air-space. This air-space increases in size as the egg evaporates or dries. The longer the egg is allowed to remain in the air, the more air will pass through the shell; and each little particle of air carries away with it some of the moisture of the egg, and thus the contents dry up and the air-space increases in size. Sometimes eggs that have been left exposed to the air in a nice clean place for a year, are found to have very little content;

and that which is left is dry and almost hard. These tissues may be pulled off the shell, especially in the case of a hard boiled egg.

Now we come to the white of the eggs, or what is called the albumen. This is said by doctors to be a very good food; but we are particularly interested in its appearance. So let us break an egg in a saucer. Notice that the white on the outside is thin and watery; in a little farther, we see a grey or whitish streak that extends all the way around the yolk, or yellow portion, but does not touch it. You will also notice that at each end of the yolk and extending from this whitish portion is a knotted portion, like a little piece of white string. We wonder what these are for, and observe that they are simply an extended

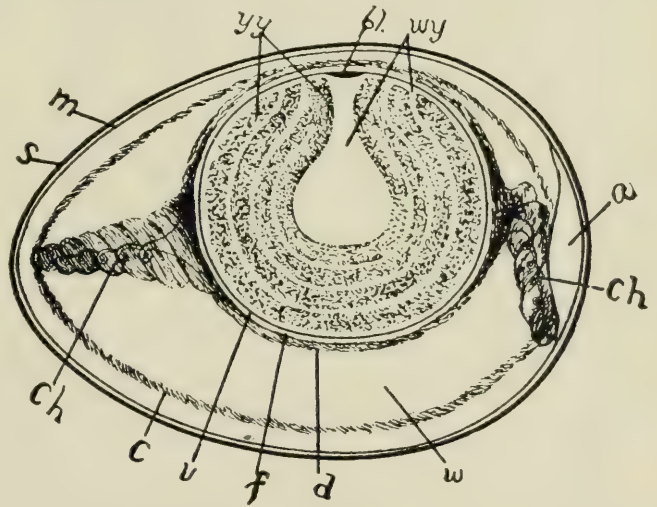


Fig. 86. Diagrammatic section of an unincubated fowl's egg: *bl* germ-spot; *yy*, white yolk, consisting of a central flask-shaped mass, and a number of layers concentrically arranged around it, the outer layer of white yolk lying immediately beneath the vitelline membrane, and connected with the central mass beneath the blastoderm; *yy*, yellow yolk; *v*, vitelline membrane; *f*, layer of more fluid albumen surrounding the yolk; *ch*, chalaze; *a*, air chamber between the two layers of the shell membrane; *m*, shell membranes, where they lie in contact over the greater portion of the egg; *s*, shell; *d*, denser albumen, which extends around the yolk, outside of the internal layer of more fluid albumen; *c*, boundary between the outer and middle portion of the albumen.

portion of this first white streak as mentioned. Inside the white streak is another watery portion. This comes in touch with the yolk. We shall now look at the yolk. Take your finger, or a blunt pencil, and try to turn it over, and you will notice that the covering of the yolk goes into all sorts of wrinkles and folds. So we find that the yolk is separated from the white by a thin layer of tissues or skin.

If you have been careful in breaking the egg, you will notice a little round spot at the top of the yolk. This spot is about the size of a pea, and is called the germ spot; and it is from this that the chicken grows when heat and other conditions are properly applied.

To study further the structure of an egg, we will have one boiled hard; and, after removing the shell and lining tissues, we will tear loose a small piece of the white at the large end of the egg. Now by continuing to pull the torn portion from the left towards the right, you will notice that this white has a spiral arrangement. This is generally considered as giving strength to the egg.

We will next examine the yolk. Take the yolk out, cut through the centre, using a very sharp knife, and you will notice a small, flask-shaped portion of the yolk, which is soft and light in color, and that the neck of the flask extends to the outer edge of the yolk. Upon this the germ rests. The hardened portion of the yolk, you will notice, is arranged in regular rings around this flask. This flask-shaped portion is lighter than the rest of the yolk, and is therefore always uppermost. No matter how you turn the egg, this spot will be on the upper surface.

Let us ponder for a few minutes over the many things we have found in the egg content. The germ, resting upon a nice soft cushion in the yolk, the yolk covered with a thin skin, ad-

joining this is a very thin portion of the white, and outside this a thicker portion. Now these two portions hold the yolk in position. If a sudden jar occurs, the yolk, or chiefly the germ, is protected by the skin of the

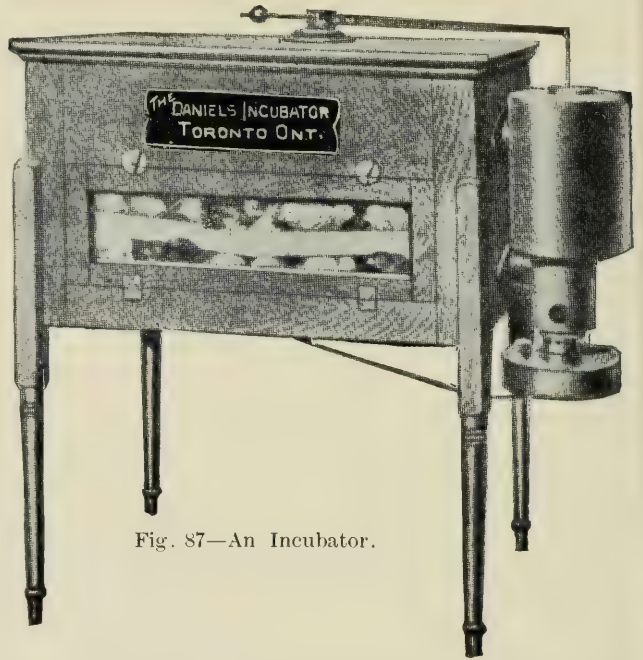


Fig. 87—An Incubator.



Fig. 88.

yolk. The thin white portion acts as a pad or cushion, and the thick white portion holds it steady. Those extended cords of the thick layer of the white act as the axis of the yolk holding it in position ; and, as you turn the egg around quickly, you twist the cords similar to twisting a string, with the result that, as soon as the egg is steady, these cords unwind, and help to right the germ spot, on the upper surface again.

No doubt by this time you are wondering, if this germ-spot and the portion of the yolk under it are so light, why the yolk does not come right up against the tissues lining the shell. But nature has guarded against this by the thick layer of albumen, which always tends to hold the yolk in position. Sometimes when the egg is left for weeks in the one position, the thick layer is overpowered, and the yolk touches the wall of the shell. If the yolk remains against the wall any length of time, it appears to become fastened to it, after which you cannot successfully hatch a chicken from the egg. Being fastened in one position, the germ cannot move properly in order to develop, the result being that the germ dies. You may say a hen sitting on eggs never moves them, but in this you are mistaken. The next hen you set, put a large pencil mark on each of the eggs; and place the eggs under a hen with the pencil marks uppermost. Next day lift the hen, and you will see that she has altered the position of the eggs.

We have to imitate the hen in running an incubator, in that we turn the eggs twice a day. But some one asks, what is an incubator? Well, it is simply a well-built box, heated by a lamp, and the heat evenly distributed over all parts of the interior, so as to give the eggs the same temperature. This box is not exactly airtight ; for you know that if this little germ inside of the egg is going to develop into a chicken at the end of 21 days, it must have air. This air, you will remember, passes through those little holes in the shell, the good air going in, and the foul air coming off in much the same manner as you breathe. Now, you will see we have this incubator ventilated in order to supply the little germ with pure air. There is another point we nearly overlooked, that is the temperature.

If you will place a thermometer under a hen, you will notice that it reads 103 degrees ; so we try to run the incubator at that temperature.

If any of you would like to see that the germ spot always stays next to the surface, you can readily do so by taking a lamp after dark, and going to a hen that has been sitting four or five days. Wrap a black cloth around the lamp chimney, but first make a hole in the cloth, much the same shape as an egg, and have the hole exactly opposite the blaze of the lamp. Put the lamp on a little box, the hole facing you. Now very carefully remove an egg from under the hen, taking great care not to turn it over. Place your finger at the ends of the egg, and hold the egg in front of the light coming from the hole in the cloth that is around the chimney. If the egg is fertile, you will see a dark spot, and from this a number of little veins running in different directions. This is the germ, and it has started to grow. Now turn the egg slowly around, and you will observe that the germ moves as you turn the egg, always resting near the surface. It is best to take a white egg to see this, as

white eggs are clearer than brown ones, and the germ is more readily seen through them. Should the egg appear clear, or no dark portion be seen, it is infertile, and will not hatch.

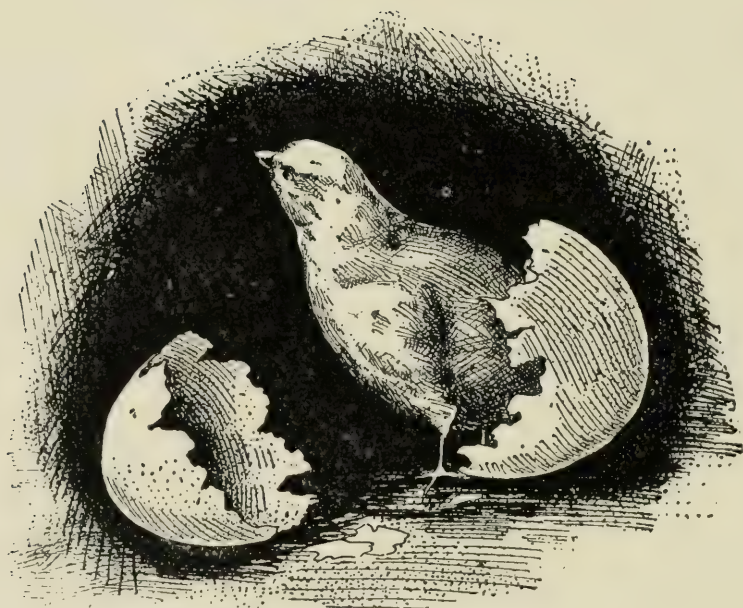


Fig. 89.—The latest thing out.

THE STORY OF WOOL.

PROFESSOR G. E. DAY.

The next time you visit a fall fair, be sure you do not come away without going to see the sheep. If you are fortunate enough to visit one of our larger fairs, such as at Toronto, London, or Ottawa, you will find the sheep pens a very interesting place. Here you will see many different kinds of sheep ; some large, some medium size, and some small ; some with white faces, some with brown or gray faces, and some with black faces ; some with their faces so covered with wool that they can scarcely see out through it, and some with no wool at all on their faces ; some with horns, and many with no horns,—in fact, the longer you look at these beautiful creatures, the more you will find to interest you. There is one thing about sheep that makes them look very different from all our other farm animals, and that is the warm coat which they wear. This coat is so thick and so warm that the sheep can stay outside in the coldest weather without minding the cold in the least, while a horse, or a cow, or a pig will shiver and look very uncomfortable indeed. Now, the horse, cow, and pig have coats, too ; but their coats are made of hair, while the sheep's coat is made of wool, and wool makes a much warmer coat than hair.

Did you ever think of what is the difference between wool and hair ? If you part a sheep's wool with your hands, you will find that it is made up of a great number of very fine wool hairs, or fibres, which grow out from the skin of the sheep so close together, and so long, that they form a coat which the wind cannot blow through. After handling the wool, you will find that your hands are quite greasy. This grease, or oil comes from the skin of the sheep, and is called "yolk." It keeps the wool fibres soft and smooth, and keeps them from tangling or matting together. It also

helps to keep out water, so that a sheep can stay out in quite a heavy shower of rain without getting its coat wet through. Then, again, if you look at these wool fibres closely, you will see that they are not perfectly straight, but that they have a wavy appearance. In some kinds of wool these waves, or bends, in the fibre are much closer together than in other kinds. Look at the two fibres shown in Figs. 90 and 91. In the first fibre there are very few waves while in the second the waves are close together. The finer the fibre is, the more waves it has, while wool with coarse fibre has very few waves.



Fig. 90.—Lock of wool, showing coarse crimp.

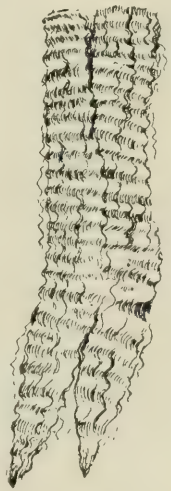


Fig. 91.—Lock of wool, showing medium crimp.

These waves, or bends, are called the "crimp" of the wool. When the waves are very close together, the crimp is said to be fine, so that fine wool has fine crimp, and coarse wool has coarse crimp.

But there is another difference between wool and hair. If you get a single fibre of wool, and take hold of the end that grew next to the body of the sheep, and then draw the fibre between the finger and thumb of the other hand, you will find that it slips through very smoothly. But if you take hold of the other end of the fibre, and then draw it between the finger and thumb as before, you will find that it seems to catch, and does not slip between the fingers nearly so easily. Why is this? It is because every wool fibre has hundreds of very, very small scales on it, something like the scales on a fish, only so small that they cannot be seen without looking at the wool with a microscope, which makes the wool fibre appear many times larger than it really is.



Fig. 92.—Wool fibre, showing scales.

These tiny scales all point towards the outer end of the wool fibre, so that when you took hold of the outer end of the fibre and tried to draw it between the fingers of the other hand, the points of these little scales caught on your fingers and made it hard to pull. The picture, Fig. 92, shows how these scales grow on the wool fibre, but the fibre and scales are made to appear very much larger than their natural size. Hair also has scales upon it, but the points of the scales on the hair are rounded, and they lie so close to the hair that they do not catch hold of anything they rub against; while the scales on the wool fibre have sharp points and rough edges, so that they catch and cling to everything they touch. This difference in the kind of scales, is the most important difference between wool and hair.

Now, when the weather grows warm in the spring, the sheep does not need its warm winter coat and so the farmer clips it all off, or shears the sheep, as we say. The wool is then sold, and is sent to the large factories where it is made into all sorts of clothing, blankets, yarn, and other goods.

Before it is made into cloth, the wool is twisted, or spun into yarn. If the wool fibres had no crimp, they would not stay tightly twisted together, and the yarn would be of very poor quality. Then the yarn is woven into cloth by machines, and the way the wool is handled in spinning and weaving causes the little scales, which we have described, to catch into one another, and the wool fibres become all tightly matted, or felted together, making a firm, strong piece of cloth. From what has been said, you will see the use of the crimp and the scales of the wool. The crimp makes it possible to twist the wool into yarn which will not easily untwist again, and the scales cause the wool fibres to stick together, or felt.

It would take too long to describe all the different things that can be made out of wool; so we shall mention only a few of the principal classes

of goods. Wool that is very long, strong, and coarse in fibre is often called "braid" wool, because it is from such wool as this that braid is made. Then there is other wool, not quite so coarse as the braid wool, but still quite long and very strong in fibre ; this is made into what are called "worsted" goods. Worsted are used very commonly in making men's clothing. Some sheep produce wool that is quite long and yet very fine in fibre. Wool that is between two and three inches long and very fine in fibre usually sells for a higher price per pound than other kinds. It is used very largely for making ladies' dress goods, such as delaines, and is often called "delaine" wool. Wool that is short and fine in fibre is used for making such goods as broadcloth, fine underclothing, tweeds, and other goods of that kind. Some wool that is long and coarse has weak spots in its fibres ; and any wool that has weak fibres cannot be used for delaines, worsteds, or braid, but is made into cheap tweeds, blankets, coarse underclothing, carpets, coarse stocking yarn, and such like. Thus, you see, there are many kinds of tweed, underclothing, blankets, and such goods, depending upon the quality of the wool that is used in making them.

Such goods as delaines and worsteds have a smooth surface. This is because the wool is put through machinery which stretches the wool hairs out straight, and they are then twisted together in such a way that all their ends are tucked in out of sight. This stretching is called "combing," and the wool fibres must be sound and strong in order that they may not break during the operation. But if you examine a piece of tweed or blanket, you will see the ends of the wool hairs standing out from the surface, making the material look rough. This is because the wool has not been combed, but has been put through a process called "carding," in which the wool is rolled up in such a way that when it is spun, the ends of the wool hairs stand out from the yarn and give a rough appearance to the cloth after it is woven. As a rule, wool that is less than two inches long is not combed, but is used for carding ; and wool that is weak in fibre will not stand combing, and therefore must also be carded. There are many other interesting things which might be said about wool, but I shall simply ask that whenever you see a sheep, you will think of what you have learned about the wonderful coat it wears, and remember that we should always be kind to these gentle and timid animals because we owe to them much of the most beautiful and most comfortable clothing which we wear.

TOMBOY—THE STORY OF A COLT.

J. HUGO REED, V. S.

I am a four year old filly. My name is Tomboy. My mother is a half-breed, and her name is Duster. My sire's name is Jim Wassen; he is a thoroughbred. Therefore I am three-quarters bred. My mother is a large white mare, a great favorite of my master, who both rides and drives her. She is a grand saddle mare and hunter. She likes to gallop across country after the hounds with my master in the saddle. She jumps over fences, ditches, stone walls and anything that is not too high; she can



Fig. 93. Tomboy's Mother, "Duster,"—26 years old.

run fast and jump better than the other horses in the hunt. She is large and strong, and although my master weighs 200 pounds, she likes to carry him as he is kind to her, rides her well, and never pricks her sides with the spurs, nor hits her with the whip, nor hurts her mouth by bearing too heavily on the reins. He has always been kind to her and fed her well, and that is why she is strong and sound and as lively as when she was young, although she has done a great deal of hard work in both harness and saddle.

The first thing I remember was one Sunday morning in May, 1898, when my master and Ernest, his stable man, came to the stall where my mother and I were. I was only about one hour old, but I was walking around the stall. They looked at me for a while, and then my master came into the stall and put his hand on me and spoke kindly. I was afraid at first and ran behind my mother, but he followed me, saying, "Poor little thing, do not be afraid, I will not hurt you;" so after a little time my fear left me, and I have never been afraid of him since, as he has always been kind to me, and provided me with a nice clean box stall with plenty of straw to lie on and good food to eat, and he never works me too hard. That morning, after looking me carefully over he said, "Well my little beauty, I am glad that you are a filly; you are tall enough but rather too slim, but time and good care will cause you to grow stouter; your knees are rather weak but they will grow strong after a while; I will call you Tomboy; and if you make as good a mare as your old mother you will do well." He then gave my mother a nice feed of warm bran and crushed oats and a drink of water. He told Ernest to clean the stall out and put in a liberal supply of clean straw. I liked to lie on the straw, and did so most of the time for a few days. Whenever I got hungry I got up and took some milk and walked around a little. My mother did not lie down for three days after I was born; she appeared to be afraid to do so for fear of hurting me. My master and mistress came to see me often, and would always pet and handle me. I liked to see either of them come, and would always walk up to them to be petted. Ernest gave my mother her food and water, and kept the stall clean and well supplied with straw. He likes horses and was very kind to us, and we both liked him, and would do what he told us. When I was three days old, my master put a little halter on me and Ernest put one on my mother and led her out of the stall. I was not afraid, but did not know what to do. My master, however, was kind and did not get angry and jerk or hit me, but petted and coaxed me; he did not expect me to lead the same as a horse that had been trained to it; so I soon learned what he wanted me to do and went along with him. They took us to the yard between the stable and the house. I forgot to tell you that we live in town. There was some nice grass in the yard; and as soon as our halters were taken off and we were given our liberty, my mother commenced to eat it. The day was fine and warm, and it was nice to be out in the open air. I began to run around my mother and kick up my heels.

My master and Ernest stood and watched us and laughed at the fun I was having. Master said, "That is right, Tomboy, have a good time but do not hurt yourself, you are not very strong yet, and a little sun will do you good." When I became tired I lay down and stretched myself out in the sun. All this time my mother continued to eat grass, but would often look to see that I was all right; she was very proud of me. After a little while some bad boys came along and threw stones at me, one of them hit me on the head and hurt me. I jumped up and ran to my mother; the boys continued to throw stones and mother became greatly excited; she galloped around and whinnied, and my master heard the noise and ran out. He was very angry at the boys, and told them that

if they ever threw stones at me again he would horse-whip them. We were then taken back to the stable. We were taken out to the yard every fine day after that and left there for a few hours, and I soon became stronger. When I was two weeks old I had my photograph taken. You can see by it that I was tall and slight, and that my knees had not yet become quite straight. When I was about three weeks old we were taken out as usual. A third man was leading my brother, who was a year old. His name is Banbury. Instead of leading us to the yard as usual they took us in the opposite direction, down a long street, until we came to a gate. They led us through this gate into a field, took off our halters and set us at liberty. There was plenty of good grass in the field and a stream of nice cool, clear water running through it. Banbury and I had any amount of fun running and kicking up our heels ; our

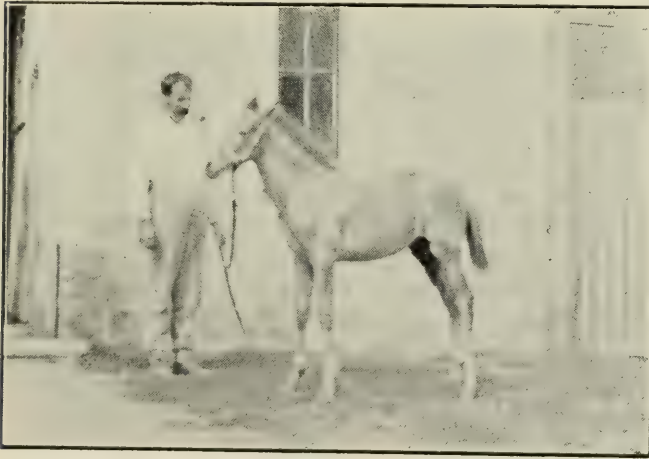


FIG. 94.—Tomboy when two weeks old.

mother would occasionally join us in our frolic, but usually she would just look on. I soon discovered that grass tasted nice, and I used to eat all I could. The weather was warm, and we stayed in the field day and night. There was plenty of grass and good water, and we had a good time with nothing to do but eat, drink, play, and sleep. After a while, the grass became rather dry and less plentiful, and the flies began to torment us during

the day time. Our master soon noticed this, and every morning, about the time that the flies were beginning to trouble us, he would mount his wheel and ride down to the gate, which he would open. Then he would whistle ; and as soon as we would hear him we would all gallop up to him, when he would put a halter on my mother and lead her out of the gate. We would follow, and he would then shut the gate, mount his wheel, and start towards home. Banbury and I would sometimes run ahead and sometimes lag behind ; but we never got far away. We all were taken to the stable and put into our stalls, the windows of which were darkened to keep the flies out. Ernest then gave us some nice new hay and crushed oats, having nailed a little box up in one corner of the stall, just the proper height for me to eat out of. I was too small to reach my mother's feed box. When evening arrived, we were taken back to the field, as the flies did not bother us now, and it was better for us to be out than in the stable, and we liked it better. This was done every day until the weather became colder in the fall, and the nights were so cold that we would be uncomfortable in the field. The flies had mostly all disappeared by this time, so we were kept in the stable at night and turned out in the day time. After a time the weather became so cold that we were not taken

to the field at all, but were allowed to run out in the yard for a few hours every fine day. The time soon arrived when I had to be weaned. I was taken to a nice stall in a part of the stable distant from my mother. I did not like to be taken away from her. Neither did she like to be left alone. I was taken to her stall and left with her for a few minutes three times a day for three days ; then twice daily for three days ; then once daily for a few days ; after which I was not allowed with her at all for a long time. By this time, I had grown quite stout and strong, and my knees had become straight, as my master said they would the first time he saw me. I was fed all that I could eat the first winter. Ernest gave me good hay and scalded chopped oats, with a carrot or two every day, and twice weekly he gave me a feed of bran. My stall was kept clean and well supplied with straw, and I was allowed to run out in the snow with Banbury every day that was not too cold or stormy. My master used to trim my feet every month. He said that the wear was not equal to the growth, and that if he did not keep them trimmed to the natural shape there was danger of them becoming ill formed and injuring me for life. He used to put a little bridle on me and leave it on for an hour or two every day. He said this was to give me a mouth. By that he meant to accustom me to the bit. I did not like it at first, but after a few days I did not mind it in the least. Then he put a set of little harness on me and left it on for a few hours daily. He soon put a check rein on the bridle. A portion of this rein was elastic. He fastened the rein to the check hook, but did not check me up tightly.

When I poked my nose out the elastic would stretch ; but when I relieved tension it drew my nose back to the proper position. He said that this would gradually teach me to yield to the restraint of the bit, give me a good mouth, and thereby make me a more valuable horse, and more pleasant to ride or drive. I did well the first winter, and I learned a great many things that came very useful afterwards. When the grass became plentiful and the weather fine in the spring Banbury and I were taken out into the country and turned into a field on the farm of Mr. B. This was about the end of May. Our master told Mr. B. to watch us closely, and if we should not do well to be sure to let him know. The grass was very nice, and there was a stream of clear, cold water running through the field. We enjoyed ourselves very much, and resumed the sports of the previous summer, as we were always great chums and never quarreled. In two or three days I began to feel unwell, my throat became sore, and I could not swallow easily. I felt cold all the time, although the weather was warm. I did not feel well enough to play with Banbury. I grew worse day by day. The soreness of my throat increased until I could not swallow anything without feeling great pain ; my eyes became sore, tears ran down my cheeks, and I could not bear to look at the sun. My joints became sore. I had a painful cough and a discharge of mucous from the nostrils. Mr. B. saw us every day. One day he said to his son, "The filly has a cold, but I guess she will soon get over it." The son said, "But, father, you promised to let Mr. R. know if anything went wrong with the colts. You know he is very fond of them, and you should send him word about it." Mr. B. said, "I'll

think of it some day when I am in town." I gradually became weaker, as I could neither eat nor drink. One day we saw our master coming down the lane, and we were both very glad. (Banbury was quite well, but was very anxious about my condition). We knew that he would do something to help me. As soon as he saw me he said, "Poor Tomboy, how you have failed. What is the matter?" Mr. B. was there, and after our master had examined me, he said to Mr. B., "Why did you not let me know that the filly was ill? You are in town mostly every day." He said that I had influenza, and that it would require very careful nursing to pull me through. He was very angry with Mr. B. for not telling him. He took both Banbury and me home. I was very weak, and we had to go slowly. When we reached home he rubbed something on my throat and gave me some medicine, which did not taste nice but did me good. He and Ernest gave me a great deal of attention, and my throat soon got better, and I was able to eat. When I got strong enough he turned us out to pasture on Mr. W.'s farm, where we remained until the weather became cold, when we were taken back to town. The following winter we both did well. One day my master put a set of harness on me and drove me out on the street. I was so accustomed to harness and to do as I was told that he had very little trouble with me. He did this a few times, and then he hitched me to a light cutter. It was something new for me to have to draw a load, but I knew that it was all right, else my master would not ask me to do it. He walked behind at first, but I went all right, so he got into the cutter and I drew him too. He drove me a little every day for a couple of weeks, and I heard him tell Ernest one day that I was pretty handy now and would never give any trouble in harness. The next spring we were again turned out on good pasture and again taken to the stable in the fall. We were well cared for during the following winter. Banbury did some regular driving, and I was driven some to continue my education. The next spring Banbury was four years old and I was three. One day a man came to the stable and looked at all the horses. He asked if Banbury was for sale, and my master said, "Yes, I will sell him; he will make an excellent lady's saddle horse." The man said that he wanted him to send to South Africa with the mounted infantry. My master then said, "Well, you can not have him, as I will not sell him for that purpose;" so the man went away, and I was glad that he could not get Banbury to send to the wars. After a little while a lady came to the office one day and asked my master if he had a good saddle horse to sell. Banbury was taken out for her inspection. She liked his looks and asked if she might ride him. My mistress's saddle and bridle were put on him, and the lady mounted and rode away. When she came back she said she liked him, that his paces were good, and he had an excellent mouth and good manners. She bought him. I was sorry to see him leave the stable, but glad that he had been bought by a kind lady who wanted him for herself. My master saw him a few months later, and I heard him tell Ernest that he looked well, that he was homesick for a few weeks, but was now quite contented and happy in his new home, that his mistress was kind to him and very fond and proud of him. One day Mr. T., a friend of my master's, asked

permission to ride me. He was told that I never had been ridden, that I was of a nervous, sensitive disposition and required very gentle, kind treatment, and that he would like to ride me first himself but was too heavy for me. Mr. T. said that he would like to try me, so a saddle and bridle were put on me, and I was taken out to a vacant lot. My master held me while Mr. T. mounted, and then led me for a while. I was afraid, as I never had weight on my back before, but while my master went with me I knew that it was all right and I went nicely. He said to Mr. T., "Now, I will let her go; be gentle with her and do not worry her mouth;" so he let go. I became nervous then and made two or three plunges. Mr. T. sat me well, was easy with my mouth, and spoke kindly to me, so I settled down and walked along quietly. Mr. T. then said, "So my lady, you thought you could unseat me, but I will teach you that I am master here." He then drew heavily on the reins and hurt

my mouth, and he hit me a smart cut with his whip, which caused me pain. This made me angry, as he had no right to punish me when I was acting nicely; so I bucked and threw him off. He alighted heavily on the hard ground; and I stood still until he got on his feet. My master came to me and caught the bridle; he asked Mr. T. if he was badly hurt, and told him that he should not have punished



Fig. 95. The colt gives a lesson.

me. Mr. T. said that he was not badly hurt and that he would mount again, which he did; and as he used me kindly I did not throw him again. The next day I heard my master tell Ernest that two of Mr. T.'s ribs had been broken by the fall. I felt sorry, but really it was his own fault. After this I was ridden daily by Ernest. He was kind to me, and I acted well. I soon became handy, and Ernest said that I was very easy to ride. One day my mistress asked if she might ride me; and my master said yes, that I was perfectly safe. So they put saddles and bridles on me and my mother, and my mistress and master rode us. After that she rode me often, and said that she liked me better than her own saddle horse. She sits me well and has very light hands. I like to have her ride me. She says that I walk, trot and canter well, and that my mouth is perfection. One day she asked me to jump a ditch, and I did it so well that she tried me over fences. I like jumping; I think I inherit the liking and ability to jump from both my parents. When the hunting season commenced, my master rode a big bay half-breed that he calls Pharoah, and my mistress rode her big bay half-bred mare, Dorothy. There are so many barbed wire fences and so many swamps around here that they cannot hunt foxes as they do in some countries; so the huntsman rides across the country with a ball soaked in oil of anise

trailing after him. He avoids swamps and barbed wire fences. Then the club comes out on horseback, and the huntsman brings the hounds out. The hounds scent the anise, and follow the course that the huntsman had gone. This is called hunting a drag. The hounds make a lot of noise, which is called giving tongue. I heard my master tell the huntsman one day to make a short run, as he wanted to try Tomboy across country, and that he would ride Duster ; that the one was too young and the other too old for a long run, and to make it about four miles. So we were taken out one afternoon. My master rode my mother, and my mistress was up on me. As soon as the hounds came in sight I noticed that my mother became excited. She pawed the ground and champed the bit and wanted to be off. I did not understand it, as I saw nothing to be excited about. There were about twenty ladies and gentlemen in the saddle. After a while the hounds scented the drag, and one of them gave tongue. My master said, " Old Cecil has found, it ; steady Duster, steady."

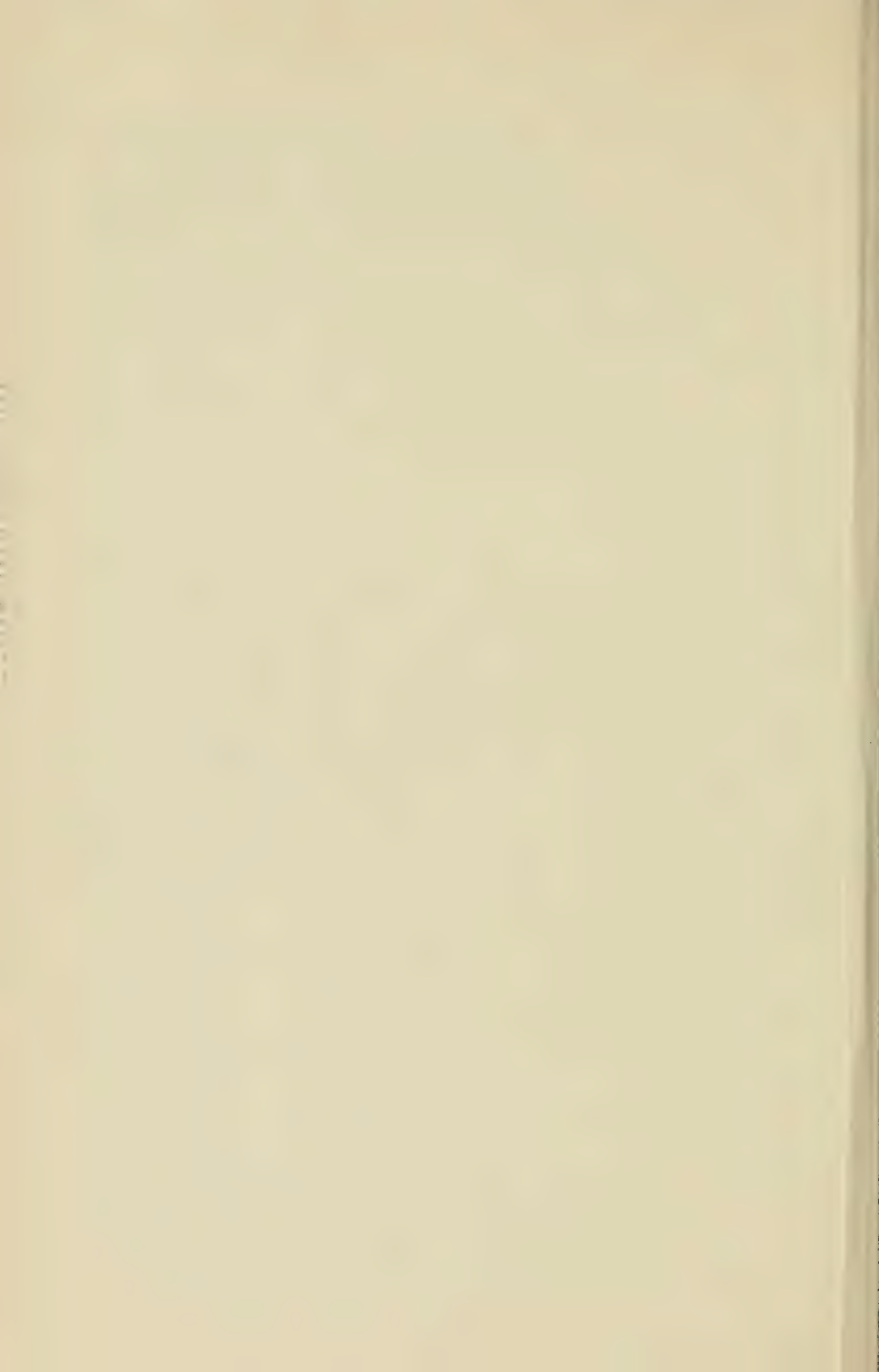
Away the hounds went over the fence. My master had his hands full controlling his mount, but he managed to steady her and said to my mistress, " Now, I will give you a lead ; steady her well at her jumps." He gave my mother her head and took the fence. I followed and off we went after the hounds. The other riders followed. My mother was very anxious to go fast, but her rider held her in, and said to my mistress, " Keep Tomboy back for a while ; we will save our mounts at first, and see if the old mare and her daughter cannot beat them all out at the finish." I soon understood my mother's excitement, as I was becoming excited too, and anxious to run to the front. Our riders held us back without being severe or cross with us, and we jumped everything that came in the way. We enjoyed the sport as much as our riders. My mistress talked to me and praised the way I was carrying her, and said that she would let me have a brush with my mother at the finish. By this she meant that she would let me try to outrun her. I would rather have gone faster, but wanted to please my mistress, and I knew that she was the better judge. Some of the riders were ahead of us and some were behind as their horses refused to jump. We went along steadily and did not make any mistakes, but took our jumps well. After we had gone about three miles we noticed those in front of us stop short. The riders took their mounts back and then turned and whipped them ; after which they ran to a certain place and balked. Two of the riders went forward over their horses heads and were lost to view, while the horses galloped over the field with empty saddles. My master said to my mistress, " They have come to a stream and the horses refuse to take water." He meant that they would not jump over the water. " It is a broad jump and our mounts will require speed to take it ; steady Tomboy and follow me, but do not whip her." He gave my mother her head, and she went fast, with me close up. We passed through the other horses and both jumped the stream with ease. The hounds had lost the scent and were running around the field without making any noise. We came to a standstill and got a rest. Our master blew his horn, when every hound raised his head and looked towards us. He blew again, and they all came to us. In the meantime, some of the horses got across the stream, but some would not take it. Master told the

hounds to hunt and Cecil again found, and gave tongue. The others soon joined her, and away they went, making a great noise. Both my mother and I were excited now and anxious to be off, but our riders controlled us until the hounds got well away, when our master said, "We are near the finish now so let us have a brush and try Tomboy's mettle." They gave us our heads and off we went side by side. I was anxious for my mistress to win; but my mother can run fast even though she is old. We left the other horses behind. There was an open gate leading into the road, and about a quarter of a mile off we saw the hounds had lost again, and we knew that this was the finish. We ran down the road very fast; and just at the last I got about half my length ahead of my mother and won.



Fig 96.—Tomboy and Duster lead the way.

I think she allowed me to do so, but she will not admit it. This was near home; so we were ridden home; and my mistress gave me great praise and said she would never allow me to be sold, but would keep me for her own saddle horse. I was glad that I had done so well, as I liked my mistress and had a good home, and a horse never knows what kind of a master he will get when he is sold. We were taken home and given a few mouthful's of water, put into our stalls, and given a nice warm mash each, rubbed until we were dry, and bandages put on our legs, and left on for about three hours. The next day we were given some walking exercise, and we both felt quite fresh. My mistress intends to ride and hunt me regularly; but my master says my mother is too old for such violent exercise, and he does not think he will hunt her again. He says he will keep her as long as she lives; that it would be mean to sell so good a servant in her old age, and that he could not bear to see her owned by any person who might not be kind to her.



ONTARIO AGRICULTURAL COLLEGE.

BULLETIN 125.

R O U P

BY

F. C. HARRISON, Professor of Bacteriology,
and DR. H. STREIT, Assistant in Bacteriology,
Ontario Agricultural College, Guelph.

PUBLISHED BY THE ONTARIO DEPARTMENT OF AGRICULTURE,
TORONTO, ONT., DECEMBER, 1902.

PRINTED BY L. K. CAMERON,
Printer to the King's Most Excellent Majesty.



Ontario Agricultural College and Experimental Farm

ROUP.

By PROF. F. C. HARRISON and DR. H. STREIT, Bacteriological Department of the Ontario Agricultural College and Experimental Farm.

The most widely spread and destructive disease affecting domestic fowls in Ontario, and perhaps in Canada, is commonly known as *Roup*, Canker, or Distemper. By some, the disease is called Cancer of the Mouth, Throat, etc., or even by the name of Fowl Diphtheria; but all these different names are given to the same disease, according as some particular symptom is more or less prominent.

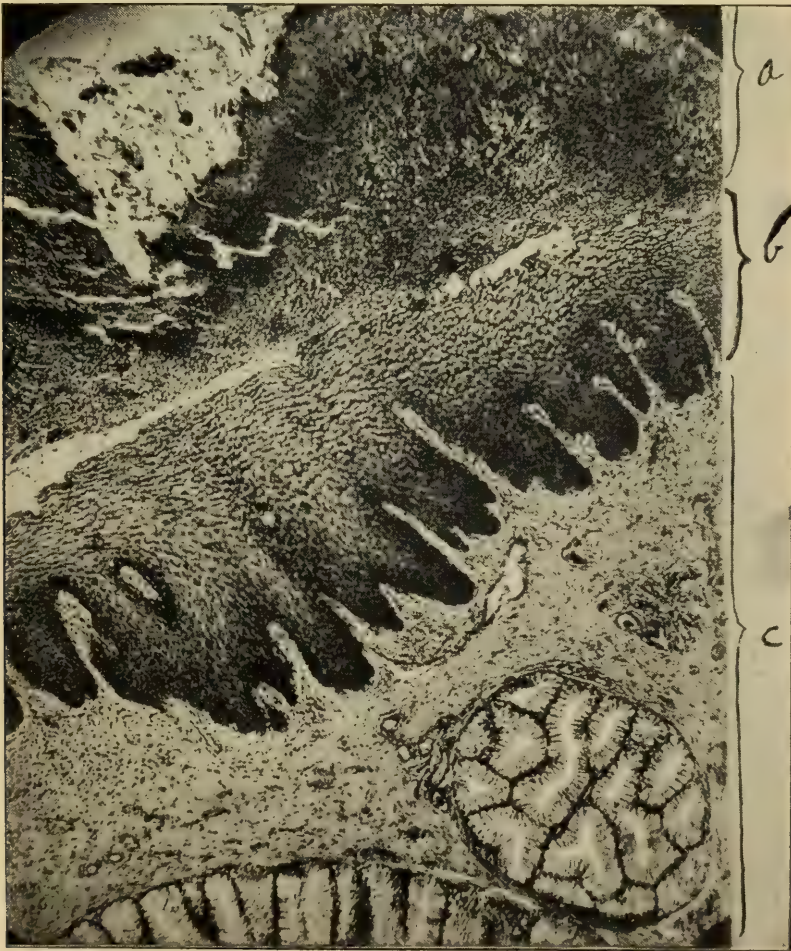


Fig. 1.—A section of false membrane of a rousy fowl. *a* False membrane. *b* Epithelium. *c* Submucosa.

Economic Importance. The economic importance of this disease is very great, as it is probably one of the greatest hindrances in the

poultry business. The direct losses from the disease vary greatly in different epidemics. Thus, in a virulent outbreak, there may be many deaths in a short time; while, in another, a flock may become infected and only a few birds die. Of much greater importance are the indirect losses; and these are apt to be overlooked by farmers or those who keep only a few fowl and pay but little attention to them. The diseased birds recover very slowly; and they remain thin, anæmic, and unfit for egg production, fattening, or breeding,—eating just as much as if they were normal and living at the expense of their keeper.

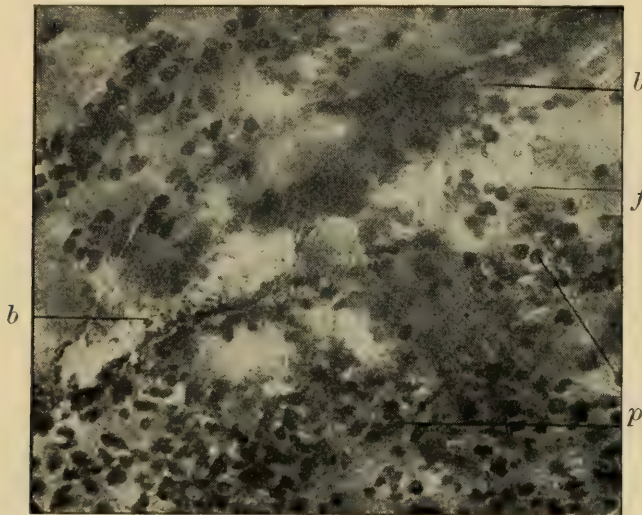


Fig. 2.—Section of a false membrane (portion of (a) Fig. 1, more highly magnified) showing pus cells (*p*), fibrous exudate (*f*) and bacilli (*b*).

GENERAL CONDITION OF ROUPY BIRDS.

The general condition of rousy birds varies very much. After the first symptom of the disease, which is usually a putrid catarrh from the nostrils, the affected fowl is generally restless, separates from other members of the flock, becomes dull, cowers in the corner of the coop, or mopes in the corner of the pen, with its head drawn close to its body and often covered with its wings.

If there is a severe discharge from the nostrils or eyes, then the feathers upon the wings or back are likely to be smeared with it, stick together, and after some time fall out; and the eyes are often shut, the lids being glued together by the sticky discharge from them.

A fowl in a sleepy condition, or moping as described, frequently rouses itself for a time, takes food, and especially water, and then gradually returns to the apathetic condition.

Many fowls having the disease in a chronic form keep their normal appetite for a long time, and seem very little disturbed physi-

cally, whilst others, especially when the face or eyes become swollen, lose their appetite, grow thinner and thinner, and finally become too weak to stand or walk around, when they lie down and die in a few days. During the last stage, diarrhoea, with offensive yellow or green discharge, often sets in and causes death in a short time.

Many poultry keepers assert that roup birds show fever; and it is certain that the head is very often hot, but the body temperature is normal, or only very slightly higher than normal.

SPECIAL SYMPTOMS OF ROUP.

By the term Roup we generally understand a more or less putrid discharge from the nostrils, which lasts for weeks or even months. The disease often follows a common cold, to which fowls, especially

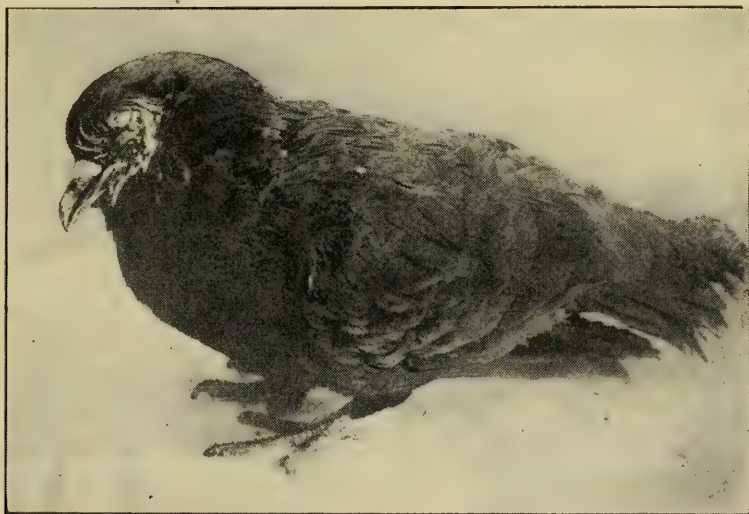


Fig. 3.—Pigeon (No. 6) thirteen days after inoculation with the roup bacillus and two days before death.

young fowls and those of the more delicate breeds, are much predisposed.

In the first stages of Roup, the birds often cough or sneeze, and the breathing is noisy, caused by the partial closing of the air passages, which become blocked with the discharge from the nostrils. When the air passages are entirely closed by the discharged products, the fowl has to open its beak in order to breathe.

Sometimes a yellowish cheese-like mass forms in the nostrils, growing quickly and pressing the upper walls of the nose upwards; and if this mass is removed, an uneven bleeding surface is left, which forms a new cheesy mass in from 24 to 48 hours.

Whilst many roup birds show only the above mentioned symptoms, others become more seriously diseased. The face of roup birds is very often swollen, especially between the eyes and the nost-

rils ; and this swelling, which is hot and sore, sometimes grows into a tumour as large as a walnut,—generally firm and hard. A bird in this condition is frequently found scratching at the tumour with its claws or wings, as if endeavoring to remove it. If the tumour grows on the inner side, towards the nasal passage, it forces the roof of the mouth downward, and the upper and lower beak are slowly pressed out of their normal position, so that the bird cannot close its mouth.

On making an incision into the tumour, we find a solid, cheesy, yellowish matter, which may be pulled out like the root of a plant ; but it usually has to be broken into small pieces in order to get it out. Around this mass, there is a more or less smooth, grey or brownish membrane that is capable of again forming a cheesy mass similar to what has been removed.

The mass itself, when not attended to, often grows into the nasal canals, and blocks them up completely. Generally, combined with the formation of the tumour on the face, there is an affection of the eyes ; or the eyes become diseased without the preliminary discharge from the nose, in which case poultry keepers speak of fowls as suffering from “ Roup of the Eyes.”

Roup of the Eyes. The first symptom of the eyes is generally an inflammation of the eyelids. These become red, swollen, and hot ; then the mucous membrane and glands of eyes become inflamed and begin to secrete a liquid,—at first clear, and then of a grey slimy, putrid character. Occasionally the mucous membrane of the eye socket is the primary seat of the infection of the eye, and the eyelids swell as a secondary symptom. It is easy to understand that the eyes may become infected from the nasal cavity, as the eye socket has free connection, by means of the lachrymal canal, with the nasal cavity, and thus the diseased products from the nostrils can pass into the eye sockets.

The secretion from the eyes is similar to that described as coming from the nostrils, *i. e.*, at first a clear liquid, then changing to a putrid grey and offensive discharge, which dries on the feathers at the side of the head, causing them to stick together or fall out. If the secretion is retained in the eye socket, it undergoes a change, becoming a yellowish, solid, cheesy mass of the same appearance as that found in the nasal tumour. This cheesy mass either forces the eye out of its socket, or the inflammation entirely destroys it. These cheese-like masses form in one or two days, and may reappear after many daily removals.

All these affections, described above, may be localised on one side ; but often both nasal passages and both eyes are affected at the same time.

Combined with the symptoms of roup above described, there often are patches of a greyish yellow exudation firmly adherent to the mouth, throat, etc. These patches are called “ false membranes ” ; and

on account of their somewhat close resemblance to the membrane which is formed in human diphtheria, it has been thought by some writers that the avian and human diseases are the same. Here, however, let it suffice to say that the weight of evidence is against this contention; but this phase of the subject will be more fully dealt with later on in this bulletin.

We may also point out that many poultry keepers who notice the false membrane on the throat and mouth of their fowls, regard the disease as quite different from the catarrhal form, and call it "canker", which is probably a popular form of the word "cancer".

Whether the disease is characterized by false membranes, offensive discharge, or cheesy masses, the cause is the same, as we have many times experimentally demonstrated.



Fig. 4.—Hen 47 ; sixty-seven days after inoculation with *B. pyocyaneus* and the day before death.

At one or several places in the mouth or throat, these yellowish, smooth or uneven membranes appear, and either remain small and disappear after a few days, or grow thicker, spread, and become firmly attached to the mucous membrane; and if they (the false membranes) are removed, an uneven, bleeding surface is exposed, which looks like a true cancer.

After the appearance of the membranes, the adjacent submucous tissue sometimes becomes inflamed, and finally the growths are found to be similar to those so often seen at the side of the face,—containing solid cheesy matter in the centre.

When the throat is blocked by these false membranes, the animal's breathing becomes abnormal, and the air passing through the throat produces loud noises. Gradually, the visible mucous membrane and the comb turn blue, and the fowl finally dies from suffocation.

The symptoms are much the same when the lungs are the seat of the disease. In dead roup fowls we have often found the higher bronchial tubes completely filled with solid cheesy matter, which prevented the air from passing into the lungs.

Occasionally cheesy matters are found in the folds of the pleura, and in other situations.

THE COURSE OF THE DISEASE.

The course of roup is usually of long duration. A simple, putrid discharge from the nose may stop in three or four weeks, and similarly false membranes may soon disappear; but generally the symptoms



Fig. 5.—Head of hen 35; eight days after infection with a culture of the rous bacillus—*a*, cheesy matter.

ast for months. When the eyelids become swollen and tumours appear, the case is usually chronic. Affected birds may be better for a few days or weeks, and then become very weak again. Damp, cold weather usually intensifies the disease.

It is well known that fowls may be more or less sick from roup for one or even several years; and these birds should have the greatest care and attention, for they are generally the cause of new outbreaks. Once introduced, roup may remain in a flock for many years. The first cold and moist nights of the fall and early winter cause all kinds of catarrhs, which in many instances are followed by roup. Roup spreads rapidly in the winter time, and may attack from 10 to 90 per cent. of the fowls in a flock. Towards spring, the disease gradually disappears; during the summer months, a few birds remain

chronically affected ; and then the first cold nights give the disease a fresh start.

Young fowls and fowls of the fine breeds are especially liable to roup. While some poultry men maintain that birds once having suffered from roup never take the disease again, most of the experimental evidence tends to show that no acquired immunity exists, as sometimes happens after other diseases. Some fowls are, however, naturally immune, and never take the disease. In the course of our own experiments, a white chicken which had never had roup, was inoculated with repeated and large doses of the roup germ, but without effect.



Fig 6.—Head of fowl 36; twenty-two days after inoculation with a culture of the roup bacillus—*a*, false membrane.

THE CAUSE OF THE DISEASE.

Many opinions have been expressed as to the cause of the disease and some of these have been based on scientific research, while others have been mere guesses. Some writers have thought that the disease is due to "Protozoa," a low form of animal life ; and others have isolated various bacteria from the disease tissues, which bacteria when grown in pure culture and introduced into healthy hens, have produced symptoms of the disease.

As roup, especially when located in the mouth or throat, resembles human diphtheria, it has been claimed that the well-known organism of this disease, the *Bacillus diphtheriae* of Klebs-Loeffler, is the cause of roup, or, as it is termed by some, "fowl diphtheria."

Statements have been made by European writers that outbreaks of diphtheria occurred in men, while at the same time poultry kept in the buildings in which the men lived were suffering from roup. They, however, do not state whether the roup commenced before the diphtheria or *vice versa*, and they give no good reasons for supposing that the outbreaks were actually connected with each other. In fact, we must state that the cases referred to, of alleged transmission of chicken diphtheria to man, are on examination found to be mere assumption, due to ignorance of veterinary pathology.

In 1898, several articles appeared in the Agricultural Press, written by H. A. Stevenson, M.D., who said, "Roup is caused by a specific germ, which appears to me to be identical with the Klebs-Loeffler bacillus," *i. e.*, the bacillus which causes human diphtheria; and in another place, he says, "I believe roup and canker to be the same disease, a disease identical with diphtheria in man."

If the above statements were borne out by experiments, and found to be correct, we should have to demand the most rigorous treatment of diseased birds; for Dr. Stevenson takes the position that diphtheria may be spread by roup birds in exactly the same manner as tuberculosis is supposed to be spread by tubercular cattle.

These statements of Stevenson are, however, not based on careful experiments, and the *human* diphtheria antitoxin which he recommended as a sure cure for roup, has been found to be absolutely worthless for that purpose.

The following experiments and observations may be cited under this head:

A student of Professor Tresbot's devoured diphtheritic membrane from fowls without contracting the disease; and Löffler, the discoverer of the human diphtheria germ, and Colin were never able to produce diphtheria in fowls by inoculation with human diphtheria germs. Gratia and Lieneaux treated roup fowls with the human diphtheria antitoxin, and secured very poor results.

We have also ourselves made a large number of experiments with roup fowls; and in about 300 roup birds that have come under our observation, we have never been able to isolate the Klebs-Loeffler bacillus, *i. e.*, the bacillus of human diphtheria. Roup fowls have also been again and again treated with diphtheria antitoxin without any result. Were the germs of human diphtheria and fowl diphtheria the same, the antitoxin would certainly have affected the diphtheria in the fowl, since it is the best known remedy for diphtheria in man.

Further, we find that the diphtheritic membranes in man and fowls are different. That of the former consists of a fibrinous exudation,—granular material, pus corpuscles, and débris of epithelial cells,—and contains the Klebs-Loeffler bacillus in great numbers; and these can readily be stained by Gram's method.

The membrane from fowls consists almost entirely of pus cells, some granular masses, debris of epithelial cells (especially swollen nuclei of these), and bacteria; but amongst the bacteria, we seldom find one that can be stained by Gram's method.

Roupy fowls never show any of the symptoms caused by the bacterial toxin (poison secreted by bacteria,) which usually follow an infection with the true diphtheria bacillus.

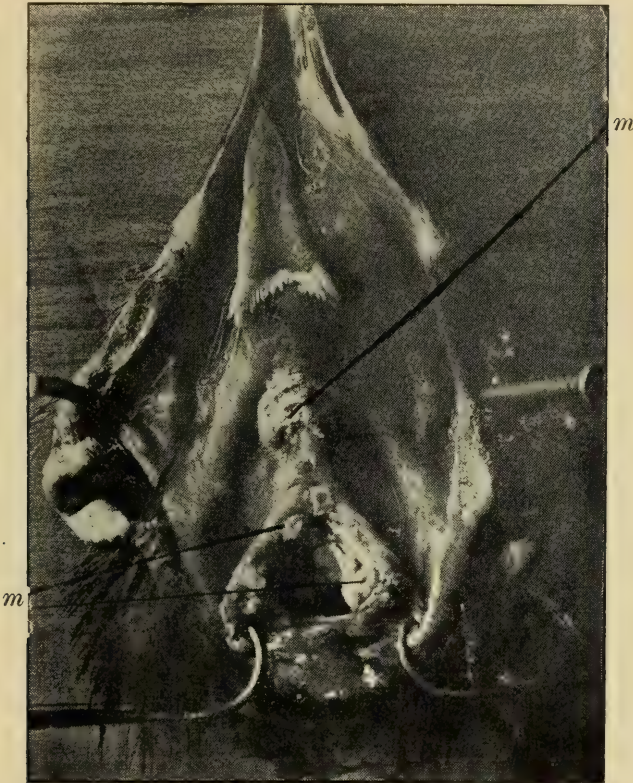


Fig. 7.—Fowl 46; throat and bottom of the mouth with false membrane (*m*), fourteen days after inoculation with *B. pyocyaneus*.

Hence we are bound to conclude, from the evidence here presented, and from other evidence we have at hand but which space alone prevents us from presenting, that *Stevenson's theory is untenable, and that fowl diphtheria is never caused by the human diphtheria germ,—the Klebs-Loeffler bacillus.*

RESULTS OF WORK AT COLLEGE.

In the present bulletin, only a brief summary of our work with rupy birds can be given. Any one wishing the full details of the experimental work may obtain them by writing to the College for the full report.

The first experiments were conducted, to find out *whether or not Roup was an infectious disease*; and, for this purpose, 10 healthy fowls which had never been exposed to infection, were confined in a cage with diseased birds; and after varying periods of time, five of the healthy birds caught the disease. Fourteen healthy birds were then treated by rubbing a portion of the false membrane, or putrid nasal discharge from roup-y birds, upon the normal, or slightly scratched, mucous membrane of the nose or eyes; and in this way, two birds were infected with typical roup.

These experiments, therefore, show the infectious nature of the disease; but the degree of infectiousness was not large. We must, however, remember that when fowls are kept under natural conditions where they are subject to cold, etc., the infectiousness may be much increased.

Having thus shown that roup is infectious, the next step was to isolate the causal micro-organism, a task of some difficulty, on account of the fact that the discharge from the nose, the false membrane, etc., is in close contact with, and likely to be contaminated by the air and food, which always contain large numbers of bacteria that find suitable material and favorable temperature for growth in the albuminous secretions of fowl.

Very many bacteria were isolated, but when inoculated into healthy chickens, they proved to be harmless.

In other infections, such as Fowl Cholera, etc., it is comparatively easy to isolate the causal organism, because it is found in the blood and organs of the diseased fowl; but in roup we find that, as a rule, the organs and blood are free from bacteria, or else if bacteria are present, they are harmless.

Without giving the results of a long-continued series of fruitless examinations and experiments, made within the last four years, we may say that at length we have isolated a germ which causes roup, with all its varied symptoms. To this germ we have given the name *Bacillus cacosmus* (ill-smelling), and shall refer to it as the "roup bacillus." A technical description of the germ will be given in a more scientific paper at a later date.

Chronic diseases, of which we have an excellent example in roup, are notoriously hard to reproduce by the inoculation of healthy animals, because in most cases of sickness there must be, not only *the causal organism*, but a lowering of the vital forces; and, to get over the difficulty, we used pigeons, which are easily infected, to increase the virulence of the causal organism and thereby assist in the infection of hens. In this way, we produced roup in hens at pleasure by inoculation with the roup bacillus, taken from roup-y pigeons.

The "roup bacillus" tends to penetrate the deeper layers of the mucous membrane or submucous tissues. Hence cultures made from swabs taken from the false membranes very rarely contain the "roup

bacillus," because the bacilli are retained in the depths of the animal tissue.

The "roup bacillus" is especially difficult to isolate in cases in which the bird has had the disease for a long time, as the tumours and false membranes contain very many other kinds of bacteria in large numbers. In our experiments, even when roup was produced in healthy fowl by inoculation with pure cultures of the "roup bacillus," the mucous discharge from the very beginning contained many kinds bacteria.

The roup germs seem capable of remaining in a sort of dormant condition in the depths of the tissues for a long time,—so long that the fowls sometimes appear convalescent; suddenly, when the constitution is weakened by a cold or other causes, the roup germs become active and the roup symptoms re-appear.

We have also found that roup, with all its varying symptoms, can be produced by the inoculation of healthy hens with the well-known

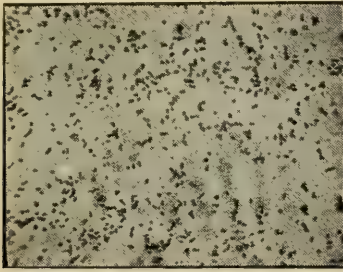


Fig. 8.—The Roup bacillus (*B. cacosmus*), from a twenty-four hour old agar culture.

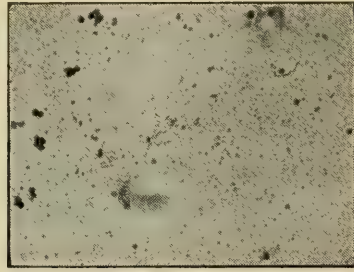


Fig. 9 —The Roup bacillus showing the flagella (organs of locomotion). Van Ermegem's method.

Bacillus pyocyaneus, or green pus germ, which we have frequently isolated from roup birds. Hence, it would seem that roup is simply a complex suppurative process; but, different from ordinary forms of suppuration, the pus in fowls appears in the form of a half or entirely solid, cheese-like, yellowish white mass, without any tendency to become soft or liquid, or to perforate the surrounding skin.

This may be proved by the injection of sterile turpentine (oil) into the eye-lids, which gives rise to inflammation and the formation of solid cheese-like matter in the depth of the tumour.

Therefore, the cheesy masses must be regarded as pus.

To sum up, roup, or fowl diphtheria, canker, etc., is a complex of suppurative processes, taking place especially in the head of fowls. This suppuration may be caused by different species of bacteria, and these may be very wide spread (e. g. *Pyocyaneus*), and thus an outbreak of roup may occur in a flock living in unsanitary conditions, without any previous introduction of the germs from elsewhere; but certainly this is the exception. More often, the disease is spread

by sick fowls introduced into healthy flocks. Germs generally are spread throughout a yard by means of the secretions, although these do not always contain the casual organism. The infected fowls are not very much different in their general appearance and condition at the beginning of the disease, and thus they often take food and water for a long time, contaminating the food, troughs and cups. As the germs cannot infect fowls so long as the mucous membranes are intact and healthy, the disease does not spread for a certain length of time, although the germs may be present almost everywhere in the yard. Then comes a change of weather, such as a cold night or the beginning of fall and winter,—and suddenly the infectiousness of the disease is increased and roup spreads rapidly among the birds. Unfavorable weather, which causes colds and other infections of the mucous membranes, directly opens the way for infection. But it is possible that the roup bacilli, having infected a number of fowls, may gain so much in virulence as to be capable of entering into the tissues of the fowl without previous colds. Like colds, other circumstances which weaken the constitution of the fowls, such as unsuitable feed or feeding, unhygienic yards, bad water supply, etc., contribute towards the spread of the disease. Once present in a poultry yard, the roup-causing bacilli cannot be got rid of, unless by very careful disinfection; and this is valueless so long as any of the fowls are diseased; and, as we have already stated, fowls often remain affected with roup, carrying the germs in a semi-dormant state, for months or years.

It is possible that just one kind of bacillus, for example, our "roup bacillus," causes an outbreak of roup; or an outbreak may be caused, as here at the Ontario Agricultural College, by several species.

TREATMENT AND PREVENTIVES.

As roup is not a specific infectious disease, that is, a disease caused by a single species of germ, it is almost impossible to prepare a preventive or curative serum. Hence this method of treating infectious diseases cannot be used in roup; and besides it would be very costly.

The germs of roup are not very resistant; they can easily be destroyed when present in cultures, or somewhere outside the animal; but in the animal tissue, they are very difficult to kill, because they penetrate into the tissue; and unless this too is killed, the germs continue living for a long time.

Roup may be cured by remedies, if the treatment is careful and judicious. Obstinate re-appearing false membranes can be successfully treated by burning the diseased tissue with a strong acid (hydrochloric acid 50 per cent. to 75 per cent.), or other caustics, such as silver nitrate. If the eyes and nose are attacked, they have to be carefully washed, at least twice a day, with an antiseptic solution such as 2 per cent. boracic acid in a decoction of chamomile flowers, or

$\frac{1}{2}$ per cent. solution of corrosive sublimate. Thus the micro-organisms are killed or, at least, the diseased products which are discharged are removed, and the irritation caused by them; also the transformation into large cheesy masses is prevented.

We had chickens badly affected with roup of the eyes, which were cured with boracic acid and chamomile. On account of the smallness of the nostrils and nasal canals, it is very difficult to get the antiseptic solutions into the nose and nose cavities; but it can be done with a small syringe. If this treatment is too troublesome, then the nostrils, at least, should be washed and opened several times a day, to allow the secretions to pass away. We have treated chickens for 14 days by daily washing with a $2\frac{1}{2}$ per cent. solution of creolin and glycerine. After the washings, small plugs of cotton wool, filled with mixture, were placed in the nostrils and lachrymal ducts. This remedy did not cure the roup in the head, although the same mixture readily kills the roup bacillus in cultures in from 2 to 3 minutes. The greatest hindrance to a sure cure by remedies which have been used locally, is the ability of the germ to penetrate into the tissue and the many secondary cavities of the nostrils which cannot be reached by the antiseptics.



Fig. 10.—Showing method of treatment of roup birds by immersion of the head in one to two per cent. solution of potassium permanganate.

Another method of treatment which gives excellent results, especially in the earlier stages of roup, is the use of a 1 to 2 per cent. of permanganate of potash. Fowls are treated in the following manner: the nostrils are pressed together between thumb and forefinger in the direction of the beak two or three times. Pressure should also be applied between nostrils and eyes in an upward direction. This massage helps to loosen the discharge in the nostrils and eyes. The bird's head is then plunged into the solution of permanganate of potash for twenty or thirty seconds, (see Fig. 10) in fact the head may be kept under the solution as long as the bird can tolerate

it. The solution is thus distributed through the nostrils and other canals and has an astringent and slight disinfecting action. This treatment should be given twice a day and continued until all symptoms have disappeared.

If there are solid tumours in the eye-lids, they should be opened so that the skin may bleed freely. The cheesy matter should be removed, and the surrounding membrane touched with a 5 per cent. carbolic acid or silver nitrate solution, and then a cotton plug filled with some antiseptic solution, put into the cavity. The cavity has to be washed out daily with an antiseptic mixture, and a fresh cotton plug put in again to prevent the cavity from healing too quickly. We have cured chickens in this way in about a fortnight.

As all these methods of treatment demand a great deal of time and care, they cannot well be used for whole flocks, but the more valuable fowls may be treated in this manner. Farmers and poultrymen should first try the permanganate of potash method of treatment as it is the easiest to employ.

Food remedies influence roup only by strengthening the fowls and assisting nature to throw off or conquer the disease.

As in other infectious diseases, the most important thing is to prevent an outbreak, or to suppress it as soon as possible. All diseased fowls should be separated from the healthy ones; and the healthy ones should be examined daily, with a view to isolate newly affected birds. After the isolation of the diseased birds, the poultry yard should be disinfected thoroughly with a 5 per cent. solution of carbolic acid, followed by a careful white-washing of the walls, etc. Slightly diseased fowls, or any of special value, can be cured, if much care be taken. Less valuable birds, which it will not pay to treat, should be killed as soon as manifest symptoms of the disease appear, especially when the face becomes swollen. These fowls, unless the best care is taken, will remain diseased for months, or perhaps years, and give rise to fresh outbreaks whenever an unfavorable season (with much wet, cold weather) occurs.

The most effective preventive for roup is to keep fowls in good sanitary conditions—in dry, roomy yards and dry, clean, airy houses which are free from draughts and can easily be cleaned and disinfected.

5126
ONTARIO AGRICULTURAL COLLEGE

BULLETIN 126.

PEAS
AND THE
PEA WEEVIL.

BY

C. A. ZAVITZ, B.S.A., Experimentalist,

AND

WM. LOCHHEAD, B.A., M.S., Professor of Biology.

PUBLISHED BY THE ONTARIO DEPARTMENT OF AGRICULTURE,
TORONTO, ONT., APRIL, 1903.

PRINTED BY L. K. CAMERON.
Printer to the King's Most Excellent Majesty.

THE ONTARIO AGRICULTURAL COLLEGE

AND

EXPERIMENTAL FARM

GUELPH, ONT.

HON. JOHN DRYDEN, Minister of Agriculture,
Toronto, Ont.

STAFF OF PROFESSORS AND INSTRUCTORS.

JAMES MILLS, M. A., LL.D.	President
H. H. DEAN, B.S.A.	Professor of Dairy Husbandry
C. A. ZAVITZ, B.S.A.	Director of Field Experiments
J. HUGO REED, V.S.	Professor of Veterinary Science
G. E. DAY, B.S.A.	Professor of Agriculture and Farm Superintendent
H. L. HUTT, B.S.A.	Professor of Horticulture
J. B. REYNOLDS, B.A.	Professor of Physics and Lecturer in English
F. C. HARRISON, B.S.A., D.P.H.	Professor of Bacteriology
W. LOCHHEAD, B.A., M.S.	Professor of Biology and Geology
R. HARCOURT, B.S.A.	Professor of Chemistry
W. R. GRAHAM, B.S.A.	Manager and Lecturer in Poultry Department
H. R. ROWSOME	Lecturer in Apiculture
M. W. DOHERTY, B.S.A., M. A.	Associate Professor of Biology
W. P. GAMBLE, B.S.A.	Associate Professor of Chemistry
M. CUMMING, B.A., B.S.A.	Associate Professor of Agriculture
W. J. RUTHERFORD	Dean of Residence and Instructor in English and Mathematics
H. STREIT, D.M.V.	Assistant in Bacteriology
W. C. GOOD, B.A.	Assistant in Chemistry
ALICE ROWSOME, B.A.	Assistant in Library and Instructor in French and German
T. D. JARVIS, B.S.A.	Fellow in Biology
G. B. MCCALLA, B.S.A.	Fellow in Physics
CAPTAIN CLARK	Instructor in Drill and Gymnastics

OFFICE STAFF

S. SPRINGER	Bursar
B. S. PICKETT	Secretary.
ANNIE HALLET	Stenographer.
F. K. DOUGHERTY	Departmental Stenographer.
W. O. STEWART, M.D.	Physician.

CONTENTS.

	PAGE.
Different Uses of the Pea Crop.....	5
Pea Growing in Ontario.....	5
Insect Enemies of the Pea Crop.....	6
Pea-Weevil.....	6
Pea Moth	6
Pea Aphis.....	7
The History of the Pea-Weevil in Ontario.....	8
Loss to Ontario in 1902 by the Pea-Weevil	10
The Decrease in Acreage.....	10
The Decrease in Yield per Acre	12
The Decreased Market Value of Weevilly Peas.	12
The Decreased Value of Weevilly Peas for Feeding Purposes....	12
The Small Germinating Power of Weevilly Peas when used for Seed.....	12
Varieties of Field Peas	13
Selection of Seed.....	16
Large and Small Seed.....	16
Whole and Split Seed.....	16
Sound and Weevilly Seed	17
Dates of Seeding	18
Seed per Acre	19
Methods of Sowing.....	19
Growing Peas with Other Crops	19
Mixtures for Green Fodder and for Hay	19
Mixtures for the Production of Grain.....	20
Peas as a Pasture Crop	20
Peas as a Green Manure	21
Substitutes for Ordinary Field Peas in Weevil-infested Districts.....	21
Grass Peas.....	21
Egyptian Peas	23
Cow Peas	24
Soy Beans.....	24
Vetches	25
Emmer.....	25
Other Substitute Crops	25
Treatment of the Pea Weevil	26
Method of Fumigation.....	26
Effectiveness of Fumigation	26
Escape of the Weevils	27
Carbon Bisulphide.....	29
Fumigation Box	30
Coal-oil Barrels	30
Bug Houses	31
Other Methods of Treating Peas	32

RECOMMENDATIONS.

The results reported in this bulletin of experiments conducted at the Ontario Agricultural College in growing peas and in combating the pea weevil, as well as the information obtained from some of the most extensive growers, merchants, millers, and exporters of peas in Ontario, lead us to make the following recommendations :

(1) That the acreage of both field and garden peas of the very best varieties be greatly increased in those sections of the Province where there are no pea weevils ;

(2) That the growing of both field and garden peas (to be ripened) in the weevil-infested districts of Ontario be discontinued for the next two years, and such crops as Early Yellow Soy beans, Grass peas, Emmer (improperly called Spelt), mixed grains, etc., be substituted ;

(3) That if any persons continue to grow and ripen peas in the infested districts, they make the best possible use of the fumigation method ;

(4) That seedsmen, farmers, and others send no infested peas into those districts of Ontario where the pea weevil does not exist ; and

(5) That farmers, gardeners, seedsmen, millers, exporters, importers, and all others who have anything to do with the growing or handling of peas in Ontario, co-operate heartily in the effort to eradicate the pea weevil from Ontario within the next two years.

ONT. AGR. COLLEGE,
GUELPH, Ont.

C. A. ZAVITZ.
W. LOCHHEAD.

Ontario Agricultural College and Experimental Farm.

PEAS AND THE PEA WEEVIL.

BY C. A. ZAVITZ, B. S. A., EXPERIMENTALIST, AND WM. LOCHHEAD, B. A., M. S.,
PROFESSOR OF BIOLOGY.

The field pea (*Pisum arvense*) is a native of Italy and has been grown in the East from time immemorial. The garden pea (*Pisum sativum*) is regarded by some botanists as a cultivated variety of the field pea. Both kinds have been extensively grown in Ontario for many years, and have been highly prized for their intrinsic value.

DIFFERENT USES OF THE PEA CROP.

Peas are used in, perhaps, a greater variety of ways than any other crop grown in this Province. They are most commonly sown alone, but not unfrequently in conjunction with oats, barley or spring wheat. The crop is occasionally pastured off the land by farm stock, and it is sometimes plowed under to increase the fertility of the soil. When harvested, the unthreshed pea crop may be used as green fodder, or cured and fed in the form of hay. The ripened peas are used extensively for feeding farm stock, or are sold for seed purposes in the foreign as well as in the home markets. Shelled peas, when either green or ripe, are prepared and used in various ways for culinary purposes. The straw of green peas is hauled from the canning factories and fed at once, or placed in the silo, or made into hay; and the straw of the ripened crop is used throughout the winter season for feeding sheep, dairy cattle, and other farm animals.

PEA GROWING IN ONTARIO.

The pea crop has undoubtedly occupied a very important place in the agriculture of Ontario. According to the reports of the Bureau of Industries, the average market value of the threshed peas grown in Ontario during the past twenty years amounted to fully eight million dollars a year. In 1897, no less than 896,735 acres were devoted to the pea crop, this being the largest area under peas in any single year. Since that date, however, there has been a gradual decrease until the year 1902, when only 532,639 acres of peas were grown. This decrease is undoubtedly due to the great damage done to the crop in south-western Ontario by the pea weevil, commonly known as the "pea bug."

INSECT ENEMIES OF THE PEA CROP.

PEA WEEVIL. Scientifically, the pea-weevil is known as *Bruchus pisorum*, a name given to it by the celebrated Linnæus, who first described the insect sent to him from America. Although called a weevil, its snout is very short; hence, it is not a true snout-weevil.

The adult beetle is scarcely more than one-fifth of an inch in length, and one-tenth of an inch in width. As to color, it is brownish-black, with white and black markings, arranged as in Fig. 1, *d*. Besides the white markings, there are two black spots on the end of its body, which the wings do not cover. When examined closely with a good magnifying glass, the feelers are found to be composed of eleven joints, the sides of the thorax are notched, and the thighs of the hind legs are thickened and provided with two spines.

The beetles make their escape from the peas either in the late summer or spring; the majority probably in the spring. Those that appear in the fall, pass the winter in the barn or under fences or rubbish, or possibly in the ground. When the peas are in blossom, the beetles appear on the vines, and the female deposits her yellow, spindle-shaped eggs on the outside of the young pods. Many eggs are frequently found on a pod, but always singly, and attached by a sticky substance, which becomes white and glistening when dry.

In a few days, the grub hatches from the egg, bores through the wall of the pod, and enters the nearest pea. Within the seed it feeds and grows.

The grub (Fig. 1, *a*) is maggot-like, being fleshy, slightly swollen in the middle, and white, with the exception of its mouth, which is brown. It has three pairs of minute legs, which are frequently overlooked. When full grown, it is about one-fourth of an inch long. It eats a circular hole on the side of the pea, leaving only a thin hull as a covering. It then lines this cavity with a thin paste, within which it changes to a pupa.

The pupa (Fig. 1, *b* and *c*) is white, but often becomes brown after the peas are threshed and fumigated. The pupal stage is the resting one, and lasts about a week, the exact duration depending largely on weather conditions. It then transforms into an adult beetle, which may either emerge from the pea immediately or remain passive within its cell, even until late in the spring.

PEA MOTH. This pea enemy, known as the pea moth, (*Semasia nigricana*) is more widely distributed in Canada than the pea-weevil, but it does not work so much injury. This tiny moth (Fig. 2, *b* and *c*) is the parent of the small caterpillars, or "worms," which are often found within the pod on the surface of partly eaten and web-covered peas. Besides inflicting injuries to the peas, these "worms" (Fig. 2, *a*) leave much excrementitious matter in the form of pellets, which render the seeds disgusting and worthless. When nearly full grown,

the caterpillars go into the ground, where they spin a fine cocoon, and remain all winter. In July, the moths emerge, and begin egg-laying a few only being laid on the young pods. The young caterpillars hatch from the eggs in about two weeks.

Late peas are injured most, and sometimes these are badly damaged. (Fig. 2, d). No reliable treatment has as yet been found to control them, but it is advisable to sow early peas, since these are least injured.

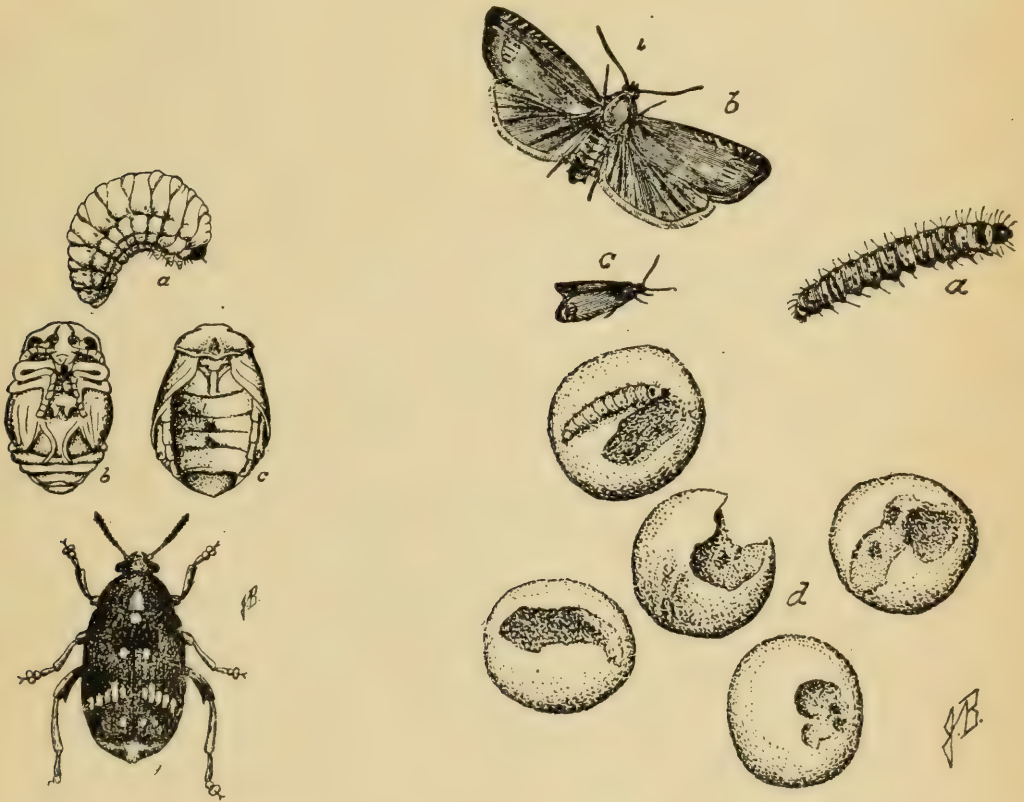


Fig. 1. *Pea Weevil*.—(a) The grub; (b) the pupa, under surface; (c) the pupa, upper surface; (d) the adult weevil. (Original.)

Fig. 2. *Pea Moth*.—(a) A full grown "worm" or caterpillar (enlarged); (b) adult moth with wings expanded (enlarged); (c) adult moth with wings closed; (d) a group of five peas injured by the caterpillar of the pea moth.

PEA APHIS. Within the past few years, the pea aphid, (*Nectarophora pisi*) appeared in several localities in Ontario, especially in Prince Edward, Lennox, Addington, and Wentworth, where it caused considerable loss. In many of the States to the south of us, the losses from this insect were very large. The life history of the "aphid" is interesting, as it spends the first part of the season on clover, migrates to peas in summer, moves back to the clover in the fall, and upon it spends the winter. In Ontario, however, it has done no serious harm to the clover crop. Fortunately it is attacked by several predaceous and parasitic insects, and by a fungus, all of which aid in keeping it in check.

THE HISTORY OF THE PEA WEEVIL IN ONTARIO.

Until recently it was the general belief that the pea weevil was a native of America; but there is a strong reason in favor of its foreign origin. It is not known to feed on any other plant than the cultivated pea, of the genus *Pisum*, which is an introduced plant of Eastern origin. It is likely, therefore, that it came from the East, whence came so many of our cultivated plants, and their insect enemies as well.

The earliest published record of the depredations of the pea weevil in Ontario, so far as we are aware, is that made by the Rev. Geo. S. J. Hill of Markham, in 1857. This gentleman won the second prize (£25) offered by the Legislature of Canada, for an essay on the insects injurious to the wheat crop. Incidentally, in that essay, allusion was made to the pea weevil, which was stated to be one of the most injurious insects to the farm. It is very probable, then, that the weevil even in the fifties was an old offender.

About 1860, the weevil was very injurious in Wentworth county. It is stated that the farmers, almost to a man, at that time gave up growing of peas for two years with the result that the weevil was destroyed. The south-western counties have nearly always suffered most severely; for frequently when the remaining portions of the Province have been entirely free from the pest, the pea crops in the south-western counties have been badly injured.

Rev. Dr. Bethune, editor of the *Canadian Entomologist*, writes us that the weevil has been a familiar insect to him for nearly forty years, and that while he was editor of the entomological column of the "Canadian Farmer," published by the late Hon. George Brown, from 1865 to 1873, he frequently had occasion to give correspondents information regarding the insect. During this whole period of nine years, the weevil was very injurious, especially in the south-western part. In 1870-71, few peas were grown in Essex, Kent, and Lambton, while good crops were common and the weevil was not abundant in the neighborhood of London. Gradually, however, and year by year, the weevil spread north-eastward; and about 1878-1880 most of the farmers in that part of the Province, south of a line drawn from Newmarket to Goderich, were compelled to give up, to a large extent, the growing of peas.

During the years 1885, '86, '87, the weevil did very little injury. The acreage devoted to the pea crop in south-western Ontario was gradually reduced during 1882, '83, and '84, and this may account for the partial disappearance of the weevil during the following years. (Fig 3, c) A few farmers, however, neither stopped growing peas nor fumigated their infested crops; and this was a great mistake, as it prevented a general eradication of the weevil. Along with the in-

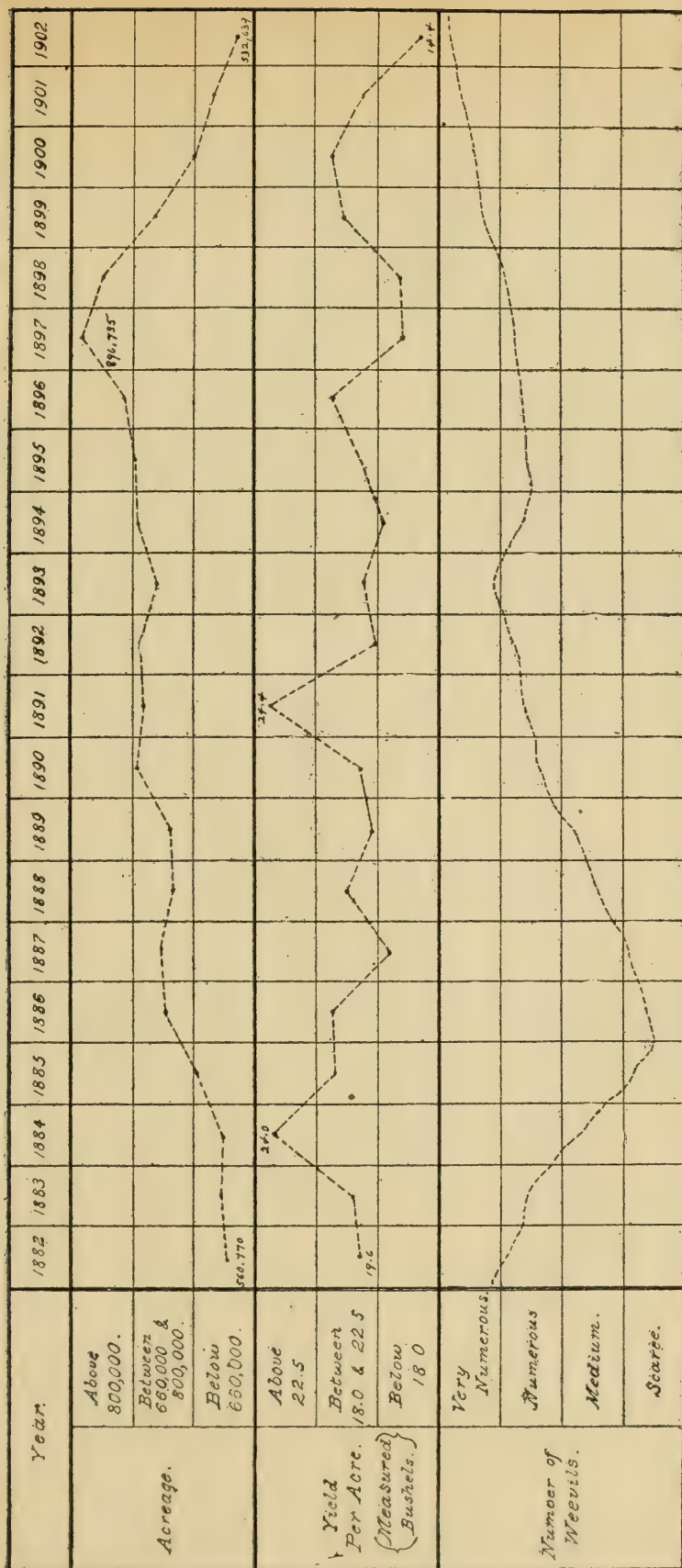


Fig. 3. Diagrams to show the increase or decrease in Ontario of (a) the acreage of peas, (b) the yield per acre, and (c) the number of pea-weevils for the last twenty-one years (1882 to 1902), based principally on the reports of the Bureau of Industries. (Original.)

crease of the acreage from 1886-1890, the weevil increased in numbers and spread rapidly along the Lake Ontario counties to the great pea-growing sections of Prince Edward and Lennox and Addington. During 1892-1893, the weevils were very numerous, but during 1894-1895 there was another decrease in the extent of the injury done. From 1896 until the present, the pest has been on the increase and many sections have given up the growing of peas. Durham, Northumberland and Prince Edward, some years ago, grew large quantities of seed for French and American seedsmen; but the depredations of the weevil became so serious that the growing of peas has, to a large extent, been discontinued in these counties.

There is a larger section of the Province, however, which is free from the weevil. (See Fig. 4.) A line drawn from Brockville to Midland separates the weevil area from the area which is practically free from the weevil. This more northern area includes such fine farming districts as the Ottawa Valley, the Temiscaming district, Parry Sound, Southern Algoma, the Manitoulin and St. Joseph Islands, and the Fort William and the Rainy River districts. This northern area could grow sufficient peas for home consumption, and for our foreign markets, until the pea weevil is eradicated in southwestern Ontario.

LOSS TO ONTARIO IN 1902 BY THE PEA WEEVIL.

It is always a difficult problem to estimate correctly the losses caused by an injurious insect, as several factors of uncertain value must be considered. In the case of the pea weevil, the factors are:

(1) *The Decrease in Acreage.* (Fig. 3). This in itself should not be considered a total loss; for if the land is not sown to peas, it is not lying idle, but is used for the production of some other (often substitute) crop. When we study the statistics of the pea crop of Ontario for the last twenty years (since 1882), we are forced to conclude that the acreage of peas in 1902 is just about one-half of what it would have been if the weevil had not proved destructive. In 1882, the total acreage of peas was 560,770 acres; in 1885, 646,081 acres; in 1888, 696,653 acres; in 1891, 752,453 acres; in 1894, 785,007 acres; in 1896, 829,601 acres; in 1897, 896,735 acres; in 1898, 865,951 acres; in 1899, 743,139 acres; in 1900, 661,592 acres; in 1901, 602,724 acres; and in 1902, 532,639 acres. There was, therefore, a gradual increase from 1882 up to 1897, then a gradual decrease from 1897 to 1902. That this decrease in acreage was due to the pea weevil there can be but little doubt. If we suppose that the area devoted to the pea crop in 1902 should have been about one million acres, according to the natural rate of increase from 1882 to 1897, then there is a decrease of about 500,000 acres in 1902. The decrease in yield would be about 10,000,000 bushels, worth about \$6,000,000.



MAP SHOWING
DISTRIBUTION OF
PEA WEEVIL
IN
ONTARIO

Fig. 4. Infested areas are dotted, the closer the dots the more prevalent the weevil. This map is based principally on reports on Co-operative Experiments throughout Ontario in 1901 and 1902, and by a correspondence carried on in 1902 by the Ontario Bureau of Industries, Toronto. (Original.)

(2) *The Decrease in Yield per Acre.* In a season like that of 1902, when all kinds of pea crops were partial failures, it is difficult to estimate correctly the loss due to the weevil alone. The average yield of peas for the past year was about five bushels per acre less than the average yield for the past twenty years; and it should be understood that the returns sent to the Bureau of Industries are given in measured bushels and not in weighed bushels of 60 pounds.

(3) *The Decreased Market Value of Weevilly Peas.* This is very marked in the south-western part of Ontario where the weevils have done so much injury for a number of years past. As there are large areas in Northern Ontario, however, where peas of excellent quality and free from weevil are still grown, Ontario's reputation as a producer of seed peas of high quality should be maintained. More than half of the territory of Ontario is practically free from the weevil; and with care, our foreign trade in seed peas of superior quality should be increased rather than diminished.

(4) *The Decreased Value of Weevilly Peas for Feeding Purposes.* As a result of a number of examinations, it is found that where weevils have infested all the peas and have afterwards escaped, the seed weighs on an average about 45 pounds instead of 60 pounds per measured bushel, or in other words, the weevils have eaten one-quarter of the peas. In the case of the small peas, such as the Chancellor variety, the injured seed weighed only 37.7 pounds per measured bushel; and in the case of the large peas, such as the Black-Eyed Marrowfat and the New Canadian Beauty, the injured peas weighed from 48 to 52 pounds per measured bushel.

(5). *The Small Germinating Power of Weevilly Peas when Used for Seed.* On an average, only about 30 per cent. of the weevilly peas will germinate. Farmers, however, try to secure sound peas, or use an increased quantity of weevily peas for seed purposes.

The average annual yield of peas per acre for twenty years (1883-1902) is 19.3 bushels, while for the last five years (1898-1902) it is 17.6 bushels. This gives a decrease of 1.7 bushels per acre; and with an area of 532,639 acres in peas in 1902, it represents a loss of over 900,000 bushels, worth over half a million dollars. These amounts do not represent the actual loss in yield, due to the weevil; they simply mean that the loss in 1902 was \$500,000 more than it would have been on the same acreage during an average year of the twenty; but the weevil was more or less injurious during all of these years; so the real loss in 1902 due to decrease in yield per acre, would probably be upwards of \$1,000,000.

If we group the losses due to the last three factors, we may get a rough estimate, by supposing that one-quarter of all the peas produced in 1902 was destroyed by the weevil and hence made less marketable, less valuable for feeding, and less germinable. The total yield in 1902 was 7,664,679 bushels, worth in round numbers only

\$3,000,000, instead of \$4,000,000, a loss of \$1,000,000. There is, therefore, a total direct loss of over \$2,000,000.

In dealing with the probable losses by the weevil we have been very conservative in our estimates. For example, we have attempted to estimate the loss occasioned by the decrease in acreage; but unless the best substitutes for the pea crop are grown, persons engaged in the bacon industry, or the export trade, will be disposed to believe that Ontario suffers a heavy loss in this great decrease.

VARIETIES OF FIELD PEAS.

Upwards of one hundred varieties of peas have been grown in our experimental grounds within the past fourteen years. The greater number of these have been tested for at least five years in succession, after which time the poorer varieties have been dropped and the more valuable kinds have been retained in the experiment.

Varieties.	Color of peas.	Average results for seven (7) years.						
		Weight of 1,000 sound peas. (2 years.)	Time between seeding and ripening.	Length of vines. (5 years.)	Peas containing weevil.	Weight per measured bushel.	Yield per acre.	
							Straw	Peas.
		Oz.	Days.	Inch's	p.c.	Lbs.	Tons.	bush. 60 lbs.
1. White Wonder	White....	9.5	97	19	34	60.4	1.2	38.2
2. New Zealand Field	White....	7.3	100	36	40	58.5	1.3	37.0
3. Early Britain	Brown....	10.3	100	39	39	57.8	1.4	36.5
4. Egyptian Mummy	White....	9.1	101	31	25	62.5	1.6	35.3
5. Tall White Marrowfat	White....	9.2	101	41	38	59.6	1.6	34.7
6. New Zealand Brown	Brown....	10.0	102	39	38	56.8	1.5	34.4
7. Potter.	White....	8.9	101	43	37	59.5	1.5	33.4
8. New Zealand Blue	Blue	8.9	99	23	36	59.7	1.1	32.9
9. Prussian Blue....	Blue	7.1	105	47	34	60.0	1.7	31.8
10. D'Auvergne	White....	7.4	96	40	38	59.1	1.3	31.3
11. White Eyed Marrowfat	White....	8.6	103	41	35	60.4	1.5	31.2
12. Common Grey	Brown....	9.8	101	40	34	56.5	1.5	30.7
13. New Canadian Beauty	White....	10.7	101	45	35	60.3	1.4	30.5
14. Chancellor	White....	5.1	94	40	36	58.5	1.3	30.5
15. White Imperial	White....	9.2	101	41	35	59.3	1.4	30.2
16. Improved Grey	Brown....	10.3	100	39	49	56.9	1.4	30.2
17. Canada Cluster	White....	8.9	101	39	29	61.0	1.5	29.3
18. Crown	White....	6.9	100	42	41	58.0	1.4	28.9
19. Black Eyed Marrowfat	White....	10.3	102	39	39	59.5	1.4	27.1
20. Golden Vine	White....	5.2	102	41	33	59.8	1.4	27.1
21. Sword	White....	5.4	104	47	33	59.6	1.6	27.1
22. Centennial White	White....	8.1	104	49	32	60.4	1.5	26.9
23. Multipliers	White....	6.9	105	50	32	60.5	1.8	26.0
24. Prince Albert	White....	6.4	109	52	31	60.9	1.7	25.1
25. Striped Wisconsin Blue	M'tl'd blue	7.1	106	46	32	61.2	1.8	25.0
26. Coffee	D'k brown	11.8	102	44	34	57.8	1.5	23.5
		8.4	101	41	35	59.4	1.5	30.6

Careful tests have been made each year, to determine the productive-ness, the quality, the resistance of the attacks of the pea weevil, etc., of all the varieties under experiment. The table here presented gives the average results of each of twenty-six of the leading varieties for a period of seven years.

It will be observed from the average results given in the table that there is a great variation in the comparative size of the peas. One thousand seeds of the New Canadian Beauty weighed 10.7 ounces, and a similar number of the Common Golden Vine variety weighed only 5.2 ounces, the weight of the former being more than double that of the latter.

The average number of days between the time of seeding and the time of ripening of all the varieties for the seven years is 101. It will be observed, however, that the Chancellor variety matured in 94 days after planting, and that the Prince Albert required 109 days to reach maturity. There was thus an average of fifteen days between the dates on which the earliest and the latest varieties reached their ripened stage.

In the average length of vines there is a great difference, the extremes being 19 inches for the White Wonder, and 52 inches for the Prince Albert variety. Owing to the extreme shortness of the straw of the White Wonder peas, they are suitable only for very rich soil which naturally grows an abundance of straw. The Golden Vine variety produces a straw which is exactly the same length as the average of all the varieties included in this report.

In each of the past seven years, very careful notes have been taken regarding the average percentage of peas of each variety which were infested with the pea weevil. In order to obtain this information, two hundred peas of each variety were opened on each examination, and the number of weevilly peas was carefully counted. It will be seen from the figures given in the table, that all of the varieties were more or less affected. Those varieties having the smallest percentage of weevilly peas in the average of the seven years' experiments were the Egyptian Mummy, 25 per cent., and the Canada Cluster, 29 per cent. The Egyptian Mummy and the Canada Cluster are varieties very similar in their habits of growth. Those varieties having the greatest number of weevilly peas were the Improved Grey, 49 per cent.; Crown, 41 per cent.; and New Zealand Field, 40 per cent. Of all the peas grown from the twenty-six varieties during a period of seven years, 35 per cent. were weevilly.

Although all the varieties of the peas grown and harvested in the Experimental Department for seven years have been submitted to the carbon bisulphide treatment, and no live weevils have been sown with the peas during that length of time, yet the percentage of weevilly peas in the resulting crops has steadily increased from year

to year. The increased amount of damage done by the weevil to the pea crop for seven years is represented by the following proportions of peas infested with the weevil: 1894, 4 per cent.; 1895, 8 per cent.; 1896, 12 per cent.; 1897, 26 per cent.; 1898, 39 per cent.; 1900, 65 per cent.; and 1901, 89 per cent. While we have been very careful to treat the peas immediately after harvest, some of the neighboring farmers have continued to grow peas, and have not fumigated the crops; hence the marked increase in the number of weevilly peas from year to year. The fact that the percentage of weevilly peas has increased in this district from less than 10 per cent. to practically 90 per cent. in a period of six or seven years indicates what is likely to occur in those districts of Ontario where the pea weevil is just getting a hold, providing no precaution is taken to eradicate it, either by fumigation or starvation. Neither in the Experimental nor the Farm Department of the College were any peas sown in the spring and allowed to ripen in the summer of the present year.

The average weight per measured bushel of all the varieties given in the table is 59.4 pounds. These results have been influenced more or less by the damage done by the weevil; but as the peas were treated immediately after harvest, they weighed heavier than if the weevils had been allowed to complete their work and escape from the peas. As a result of careful examinations which we have made of peas, all of which had been infested and from which the weevils had escaped, we found the weight per measured bushel varied from 38 to 52 pounds according, largely, to the size of the peas; the smaller the peas, the greater the amount of damage done by the weevils.

It will be seen that the average amount of straw produced by the different varieties varied from 1.1 to 1.8 tons per acre. For the average soil of Ontario, those varieties which produce a medium to a large amount of straw, usually give the best satisfaction.

There is, perhaps, no result of the varieties here presented which is more striking than the yield of peas per acre, the highest being 38.2 and the lowest 23.5 bushels. It must be remembered, however, that the White Wonder variety, which stands at the head of the list in yield of peas, is not suitable for the majority of Ontario farms, owing to its short growth of straw. The Egyptian Mummy variety produces a large yield of both seed and straw, but the straw is coarser than that of most other varieties. It will also be remembered that the individual peas of this variety are quite large in size, and that the percentage of weevilly peas was less than that of any other variety.

Within the past nine years, ten varieties of field peas which have given good results in the trial grounds at the college, have been distributed throughout Ontario for co-operative experiments. These

experiments have been successfully conducted on five hundred and seventy-one Ontario farms. Those varieties which have given the largest average yield of grain per acre, each producing upwards of 25 bushels, are the Egyptian Mummy, Chancellor, Prussian Blue, and Striped Wisconsin Blue; and those varieties which have given an average yield of between 24 and 25 bushels per acre are the Early Britain, the Canadian Beauty, and the Canada Cluster.

Each experimenter has been asked to examine the peas carefully for the weevil by splitting open 200 peas from each plot and counting the number of weevils in the form of either little white worms or darkish brown beetles.

From the reports received, we find that, with the exception of a very few scattered places, there is no pea weevil north and east of a line drawn from Brockville to Midland. The accompanying map (page 9) shows the distribution of the insect throughout Ontario, based largely on the reports of our co-operative experimenters for the past two years (1901 and 1902). Reports have been received from all of the districts in New Ontario, and indicate something of the great possibilities of that country in supplying peas of superior quality until the pea weevil can be eradicated from south-western Ontario.

SELECTION OF SEED.

LARGE AND SMALL SEED. An experiment has been conducted for five years in succession to ascertain the relative value for seed purposes of large and small peas of the same variety. In each of five years, a certain number of large sound peas were carefully selected and counted. A similar number of small sound peas were selected at the same time and from the same variety. The small peas were usually about one-half the size of the large ones. In each year, both lots were sown at the same time and on uniform plots of equal size, situated side by side.

The average results for the five years were as follows: Yield of the large seed, 30.3 bushels of grain and 1.3 tons of straw per acre, and that of the small seed, 23.9 bushels of grain and 1.1 tons of straw per acre. A certain number of large peas, therefore, gave 26.8 per cent. more grain, and 18.2 per cent. more straw than a similar number of small peas of the same variety in the average of five years' experiments.

WHOLE AND SPLIT SEED. Many farmers thresh their peas with a grain separator and part of the peas are split in the process of threshing. Some farmers carefully separate the split peas and sow nothing but whole seed; while others sow their peas without making this separation. An experiment has been conducted at the college for eight years in succession by sowing on uniform plots equal quantities of whole and split seed of the same variety. The average results for

the eight years were,—the whole seed, 30.7 bushels of grain and 14 tons of straw per acre, and the split seed, only 10 bushels of grain and 3-5 of a ton of straw per acre.

SOUND AND WEEVILLY SEED. Many observers have noticed frequently that the weevil is not full grown when the peas are harvested, and has not eaten much of the substance of the pea. We have also observed this fact; but very frequently we have observed that the grub is full grown and in the pupa or the imago state, and has done practically all the harm that it is capable of doing.

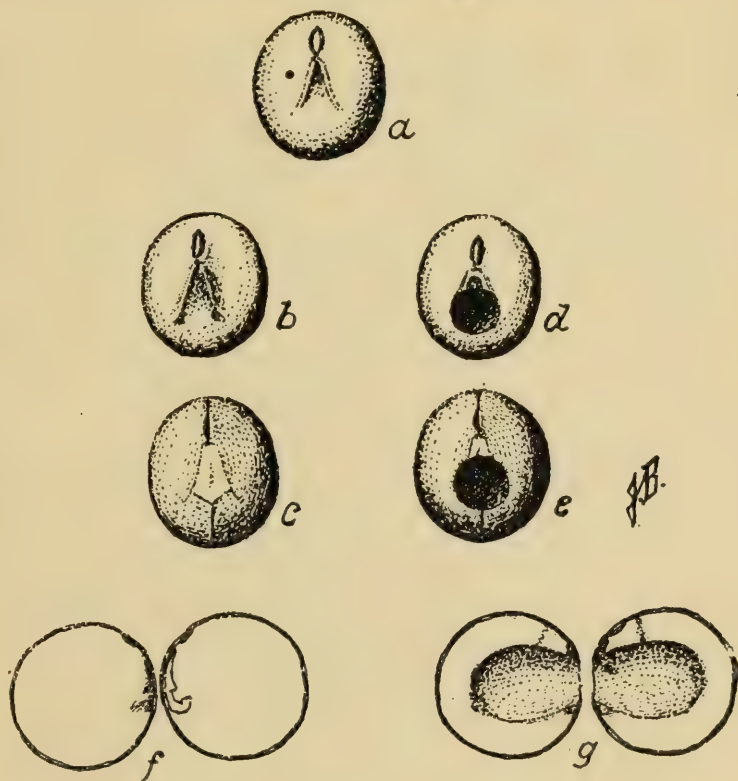


Fig. 5. (a) An infested pea showing the spot where the weevil entered; (b) a pea not infested, with "skin" on; (c) same as (b) but with "skin" removed; (d) an infested pea showing how the germ is often destroyed by the weevil, "skin" on; (e) same as (d) but "skin" removed; (f) an uninfested pea opened up into halves showing the germ; (g) an injured pea opened up, showing how the weevil often destroys both the food and the germ. (Original.)

When the grub is not full grown, the fumigation of the peas will preserve them from further injury; but when the weevil has reached the pupa stage, it has done all the injury of which it is capable.

It is frequently stated that the grub, when working in the pea, avoids the germ or embryo, and that peas which are bored with the weevil are as valuable for seed as those which are not thus injured. Such statements are wholly incorrect. On examining many hundreds of "weevilly" peas at various times, we have found that the great majority of the seeds have their germs completely destroyed, and that

the grubs show no inclination whatever to avoid the germs. (Fig. 5). Moreover, germination tests, carried out on several occasions with injured seeds, have proved conclusively that but a small percentage of them germinate, and a still smaller percentage develop into vigorous plants. In 1897, we found that about three-fifths of the peas of the Marrowfat variety, which had been injured, did not germinate, and that with the Golden Vine variety only thirteen per cent of the peas germinated. If a person were sowing weevily seed of the Golden Vine variety, it would be necessary to sow 15 acres of peas in order to get as many plants as would be produced from sowing two acres with sound seed.

The material has been stored within the seed by the plant for a purpose, and that is, to serve as a food supply for the germinating plantlet. Not until the plantlet has developed both a root system and a leaf system can it prepare food for itself. Up to this period it is entirely dependent on the food stored up in the seed; and it is plain that seeds which have a large portion of their food eaten by the weevil will stand but a poor chance of producing good plants.

DATES OF SEEDING.

Peas were sown in our experimental plots on six different dates, in the spring of each of six years previous to 1901. One week was allowed between each two seedings. In the average of the six years, the first seeding took place on April 18th, and the last seeding on May 23rd. The average of grain per acre from the six different seedings was as follows:—1st seeding, 26.5 bus.; 2nd seeding, 30.1 bus.; 3rd seeding, 28.8 bus.; 4th seeding 25.5 bus.; 5th seeding, 21.5 bus.; 6th seeding, 19.5 bus. The peas from the different seedings were examined, and it was found that as the season advanced, the percentage of peas containing weevils decreased slightly. In order to get more complete information on this subject, peas were distributed for co-operate experiments throughout Ontario in 1899 and again in 1900, and were sown on four different dates with two weeks between each two seedings. The first seeding took place in the latter part of April and the last seeding in the early part of June. The following are the average results of the various tests made over Ontario for two years:—

Seeding.	Per cent. of Weevilly Peas.	Bushels of Peas per Acre.
1st Seeding.....	79	21
2nd Seeding	67	17
3rd Seeding	57	13
4th Seeding	41	9

It will be seen that the decrease in the yield of grain per acre is more marked than the decrease in the percentage of weevilly peas.

SEED PER ACRE.

There is a great difference in the comparative size of the peas of different varieties and also a considerable difference in the character of growth of the plants of the various kinds. It is impossible, therefore, to state any definite amount of seed which will always give the best results with all varieties. While we have obtained excellent results from sowing 2 bushels of the Golden Vine, Chancellor, and Sword peas per acre, which are small seeded varieties, we have found that it is necessary to sow $3\frac{1}{2}$ bushels per acre of the large seeded varieties, such as, the Black-eyed Marrowfat, and New Canadian Beauty, if we wish to get equally good returns.

METHODS OF SOWING.

Thirty experiments have been made, comparing the results of sowing peas broadcast and with a grain drill. The land has been in a good state of cultivation in every instance. A spring tooth cultivator, which slightly ridges the land, has generally been used immediately before sowing. The average results of the thirty experiments, show that the land on which the seed has been sown with a grain drill, has produced one and one-third bushels per acre more than the land on which the peas have been sown broadcast.

GROWING PEAS WITH OTHER CROPS.

MIXTURES FOR GREEN FODDER AND FOR HAY. For six years in succession, peas, oats, barley, and spring wheat were sown separately and in eleven different combinations, for the purpose of ascertaining whether or not better results could be obtained from growing certain crops together than by growing the same crops separately; and also of finding out which mixtures would give the best results for green fodder and for hay. It was found that in fully 90 per cent. of the experiments, the grains which were grown in mixtures gave a larger yield of both green fodder and hay per acre than the same grains sown separately. In the average results of six years' experiments with eleven different mixtures, the greatest yield was obtained from a mixture of peas and oats.

In another experiment conducted for six years, in which nine different proportions of peas and oats were used, it was found that the most satisfactory results were obtained from a mixture of two bushels of oats and one bushel of peas, or a total of three bushels of seed per acre.

Among all the different varieties of peas and oats which have been grown at the College, a few of the most suitable kinds have been selected and grown in combination in order to find out which varieties give the best results for fodder purposes. In an experiment which has been conducted for five years in growing three different

mixtures of peas and oats, comprising early, medium, and late varieties, we get the following results in length of time required to produce fodder of the best quality, and in yield of green fodder per acre: Daubeney oats and Chancellor peas, 70 days, 5.9 tons; Siberian oats and Prussian blue peas, 77 days, 6.9 tons; and Golden Giant oats and Prince peas, 84 days, 6.1 tons. The *Siberian oats and the Prussian Blue peas* form a mixture which has given the best general satisfaction of all the varieties grown together for fodder. By sowing this mixture at different dates in the spring, the time in which the fodder can be used to good advantage can be considerably extended.

Co-operative experiments were conducted over Ontario for five years in succession to test the value of peas and oats (2 of oats and 1 of peas) as compared with tares and oats (2 of oats and 1 of tares) for green fodder. The average yield of green fodder from each acre per annum was 7.9 tons from the former, and 8.2 tons from the latter. It will, therefore, be seen that the mixture of tares and oats surpassed the mixture of peas and oats by an average annual yield of 600 pounds of green fodder per acre.

In those districts of Ontario where the pea weevil does not exist, peas and oats can be grown together satisfactorily for the production of either green or dry fodder. In those portions of the Province where the pea weevil is troublesome, spring tares may be used instead of peas to mix with oats. If, however, peas and oats are grown together for green fodder in the weevil-infested districts, the crops should be cut about the time that the peas have reached the blossoming stage.

MIXTURES FOR THE PRODUCTION OF GRAIN. In the trial grounds at the College, peas, oats, barley and spring wheat were grown separately and in eleven different combinations for the production of grain. This experiment was conducted in duplicate for six years. A mixture of oats and barley gave the greatest yield (2,261 lbs.) of grain per acre; a mixture of oats, barley and peas gave the second highest yield (2,101 lbs.) of grain per acre; and a mixture of oats and peas gave the fifth highest yield of grain (1,988 lbs.) per acre.

On examining the peas which were grown with the oats, wheat, and barley, we found weevils; but the percentage of weevil was not quite so high as where the peas were grown by themselves.

PEAS AS A PASTURE CROP.

In 1900 and again in 1901, we tested oats and peas, both separately and in combination, for pasture purposes. When the crops were about twelve inches high they were pastured off by cattle. That the green oats were eaten more readily than the green peas was quite noticeable. These crops did not prove very satisfactory as cattle pastures. From observations made we believe that a mixture of oats and peas would perhaps make a suitable pasture for sheep, and that either

peas alone or a mixture of peas and oats would furnish a good pasture for swine.

PEAS AS A GREEN MANURE.

An experiment was conducted in different parts of the experimental grounds for four different years, to ascertain the relative value of peas, buckwheat and rape for plowing under as green manure for fall wheat. These crops were sown at such times that they would reach the best condition for plowing under by the end of July. After the crops were plowed down each year, the land was cultivated on the surface three or four times during the month of August and the wheat was sown on or about the first day of September.

As the result of four experiments, the average yield of wheat per acre per annum was 36.1 bushels on the pea land, 30.4 bushels on the rape land, and 29.6 on the buckwheat land. It will, therefore, be seen, that the land on which field peas were used as a green manure produced $6\frac{1}{2}$ bushels per acre more than similar land on which buckwheat was used for plowing under.

SUBSTITUTES FOR ORDINARY FIELD PEAS IN WEEVIL-INFESTED DISTRICTS.

Owing to the ravages of the pea weevil in Southern Ontario, the importance of using substitute crops is becoming pretty generally recognized. Several varieties which might be classed under this heading have been grown in our experimental plots for several years in succession, the results of which are here presented :

GRASS PEAS. The Grass Pea is a leguminous plant, which produces long, flat vines, slender leaves, white blossoms, medium-sized pods, and hard, angular, white or greenish white, seeds (Fig. 6). It is entirely proof against the attacks of the pea weevil. In many respects it resembles the bitter vetch (*Lathyrus sativus*), of Europe, which, however, has blue flowers, and brown seeds. It also appears to be free from the poisonous principle which the bitter vetch is said to possess. This is borne out by scientific investigations which have been made, and by the extensive and satisfactory use of the Grass peas as a food for farm stock. They are highly prized as a regular farm crop in some sections of Southern Ontario where they have been extensively grown and fed for several years. They have been largely used as a substitute for the ordinary peas in some of those sections where the pea weevil has been doing serious damage for many years. In 1902, however, Grass peas, as well as nearly all other leguminous crops, were a partial failure, owing to the cold, wet weather of the summer. The yield of the Grass peas for 1901 was also below the average in some localities, owing to the excessively hot weather at the time of blossoming. For feeding purposes, they seem to compare favorably with the ordinary field peas. They are usually sown

alone, but sometimes with oats and barley. The crop may be used as green fodder, or as hay, or may be ripened for the production of grain, for which purpose, one and one-half bushels of seed per acre are usually sown with a grain drill. The straw is richer than that of any of the grain crops; and the peas are very hard, but, when ground, make a rich meal that is relished by cattle, sheep, and hogs. The meal of the Grass pea, being rich in flesh-forming constituents, should form not more than about one-third of the entire meal ration for farm stock. In this respect, it is very similar to the meal of ordinary field peas. Grass peas, however, cannot take the place of garden peas for table use, nor of field peas for the export trade.



Fig. 6. The *Grass Pea*, showing the thin, grass-like stems, the white flowers, and the pods containing white, angular peas. (Original.)

The Grass peas have been grown in the trial grounds at the college for at least nine years, and have given good results, except in 1902, when they were a partial failure owing to the cool weather and excessive rainfall. In the average results of tests made for a period of seven years it is found that the annual yield of grain has been 25.7 bushels, and the yield of straw 2.2 tons per acre. In 1900 the yield was slightly over 43 bushels per acre. The grain has been exceptionally heavy, the average weight per measured bushel being about 64 pounds. In comparing the results of the Grass peas with the Golden Vine peas (the common, small, white pea of Ontario), for a period of seven years, we find that the latter has given an average annual yield of 1.4 bushels of grain per acre more than the former; but that the former has given a yield of 4-5 of a ton of straw per acre, and grain which has weighed fully four pounds per measured bushel more than the latter.

In the average results of 27 co-operative experiments conducted throughout Ontario in 1901, the Grass pea gave about 3-4 of a bushel per acre less than the Early Britain variety, and 1-2 bushel per acre more than the White Wonder variety.

To compare the value of Grass peas and Common Tares, or vetches, for green fodder, seed of these varieties was distributed throughout Ontario for co-operative experiments in the years 1897, 1898, 1899, 1900, and 1901. The average results of these experiments for the five years were Grass peas 6.7 tons, and the Common Tares, or vetches, 6.8 tons per acre.

EGYPTIAN PEAS. The Egyptian pea is a leguminous plant, grown extensively in the Mediterranean regions, and in Central Asia. It has many common names, such as the Coffee pea, Chick pea, Idaho pea, Gipsy pea, etc., and is scientifically known under the name of *Cicer arietinum*. It has been used as feed for cattle, and also as an article of human food for upwards of 3,000 years. The seed is somewhat larger than that of the common pea, and is enclosed in a short, thick, hairy pod, there being from one to two peas in each pod. The plant itself is seldom used except as a soil renovator, but the yield of grain is large, and is ground into meal which makes a very valuable stock food when fed in much the same way as cotton seed meal. The straw is of little value. As a human food the peas are used in various ways. The ripened grain is sometimes prepared for the table in much the same way that we prepare our Canadian beans for culinary purposes. It is also sometimes roasted and used as a substitute for coffee.

The average results from growing Egyptian peas in our experimental department are a yield of one ton of straw and 35.6 bushels of grain per acre, the grain weighing a little over 62 pounds per measured bushel. It will, therefore, be seen that the Egyptian pea is a large yielder of grain. It is, however, slow in reaching maturity, and pos-

esses straw which is short and of poor quality. The crop is usually slow in maturing, requiring about two weeks longer to ripen than ordinary field peas. As the plants are usually short in growth, the Egyptian peas are suitable only for very rich soil. As was the case with nearly all of the leguminous plants, the Egyptian peas were a partial failure in 1902, owing to the unusually cold, wet weather.

Egyptian peas were distributed for co-operative experiments throughout Ontario for four years in succession. In the average of 180 successfully conducted experiments, the annual yield was found to be only 21.1 bushels per acre. So the Egyptain pea does not seem to be suitable for the average soil of the Province.

COW PEAS. Nearly all the varieties of Cow peas (*Vigna Sinensis*) require such a long season of growth that they are suited only to the warm climate of the south. A few of the earlier kinds have been grown in the Northern States and have been tested at our experiment station at Guelph. We have as yet, however, been unable to find any variety of Cow peas on which we can depend to produce ripened grain, as our season is short, and it is only in exceptional years that even the earliest varieties of Cow peas will mature their seed.

SOY BEANS. The Soy beans (*Glycine hispida*); also known under the names of Soja beans, Coffee beans, Idaho peas, etc., have been cultivated in China and Japan for a great length of time. The Soy bean is an annual legume; the plants have an upright growth and are almost completely covered with short hairs. The seed is generally sown at the rate of about one-half bushel per acre in drills from 2 to 3 feet apart, which are cultivated in a similar manner to our Canadian beans. The crop is used for green fodder, or is allowed to ripen for the production of grain, which is exceedingly rich, and when ground into meal is considered about as valuable as cotton seed meal for feeding purposes.

Eight varieties of Soy beans have been imported and grown in our Experimental Department. Some of the varieties have proved to be entirely unsuited for Ontario, owing to the long season required to reach maturity. The Early Yellow Soy bean, however, has given good satisfaction as a grain producer, and the Medium Green variety for the production of green fodder. The average result from growing the Early Yellow Soy beans for a period of seven years, has been 17 bushels of seed per acre. In the production of green fodder, the Early Yellow variety has produced an average of 8 and the Medium Green variety an average of 9.3 tons per acre for the same length of time.

The Early Yellow Soy beans were distributed over Ontario last year for co-operative experiments, and the average yield of grain as produced on thirteen Ontario farms was 21.4 bushels.

We believe it would be a decided advantage to Ontario farmers to grow the Early Yellow Soy beans more generally for the production of grain for feeding purposes; and the Medium Green Soy beans for placing in the silo with corn.

VETCHES. Both the Common Vetches and the Hairy Vetches are serviceable when grown alone or with oats or barley for the production of green fodder, but are not suitable for the production of seed for feeding purposes.

EMMER. This is a species of wheat, known under the scientific name of *Triticum dicoccum*. Emmer is grown at the present day in Switzerland, Germany, Russia, Spain, and some of the other European countries. When the grain is threshed, the heads break at the different joints, leaving the grain in the chaff as closely clasped as ever. To secure the clean seed, special machinery is necessary to separate the chaff from the grain. The flour obtained is said to produce a coarse bread. It is doubtful if Emmer will ever be grown extensively for flour production in Ontario, but the indications are favorable for its becoming a regular and valuable crop for stock feeding. The grain, when ground with the chaff, appears to make a meal of good quality, and the straw is considered by many to make very valuable feed. Emmer is incorrectly called Spelt, or Speltz, by many seedsmen and farmers in Ontario and in the Northern States. The true Spelt (*Triticum spelta*) is quite distinct from Emmer, and is generally considered much inferior.

Different varieties of both Emmer and Spelt have been grown in the experimental grounds at Guelph within the past thirteen years, the former producing good, and the latter, poor results in nearly every case. In the average results from growing Emmer in the trial grounds for the last three years, the yield of grain has been upwards of 2,300 pounds per acre, which is about equal in weight to 68 bushels of oats, or 48 bushels of barley.

Emmer has been distributed throughout Ontario for two years and tested with other kinds of spring wheat. The Emmer surpassed the Wild Goose spring wheat in yield of grain per acre by 46 per cent. in the average of thirty-nine co-operative experiments in 1900, and by 63 per cent. in the average of thirty-one co-operative experiments in 1901. It will, therefore, be seen that Emmer is a large yielder of grain, and that it might be well to give it a trial, especially in those sections where the pea weevil is troublesome.

OTHER SUBSTITUTE CROPS. Besides the different varieties of crops here described, an increased area of our prominent cereals, such as oats, rye, six-rowed, two-rowed, and hullless barley, might be grown, either separately or in various combinations. These crops are too familiar, however, to require any detailed description.

Mixtures composed of oats and barley; oats, barley, and Wild Goose spring wheat; or oats, barley, Wild Goose spring wheat, and Grass peas, which are sown and allowed to ripen, usually yield more per acre than any one of them when grown by itself, or than peas and oats when grown in combination. Mixtures of oats and tares

and of oats and Grass peas, are sometimes used instead of oats and field peas for the production of green fodder and of hay.

TREATMENT FOR THE PEA WEEVIL.

Within the past seven years about thirty different treatments of peas have been made in the Experimental Department for the destruction of the pea weevil. In handling the crop, care has been taken throughout to pull the peas at the proper time, to haul them to the barn when dry, and to thresh them as soon as possible. The late varieties have usually been threshed immediately on coming from the field, but the early varieties have sometimes remained in the barn for a few days, or perhaps for even a week. The threshing has usually been done with a machine, but occasionally with a flail.

METHOD OF FUMIGATION. Immediately after threshing the peas were put into cotton or jute bags. As soon as thirty bushels of peas were threshed they were placed in a fumigation box for treatment. One pound of carbon bisulphide was poured out into three flat pans, which were placed on the top of the peas; the cover was then put on the box and weighted with heavy stones. After forty-eight hours the cover was removed and the box ventilated. The pans had become dry, as the liquid had changed into a gas, which, being much heavier than air, had sunk down amongst the peas penetrating them and killing the weevils. The quantity of carbon bisulphide used by us was larger than that usually recommended, as a pound or a pound and a half is generally considered sufficient for 100 bushels of peas, but we wished to err on the safe side.

EFFECTIVENESS OF FUMIGATION. Only once during the seven years did we find live weevils after treatment. In this instance, the treatment was repeated by using one and one-half pounds of the liquid, but again a few live weevils made their appearance. After a third treatment, however, with two pounds of the liquid, no live weevils could be found. We were never able to account for the ineffectiveness of the treatments at this particular time. On all other occasions, the insects were destroyed by the first treatment, no matter whether they were in the larvae form, in the pupa stage, or had become fully developed. We find, from correspondence with a large number of exporters, that the treatment with carbon bisulphide is almost always effectual in killing the weevils with one treatment. One of our exporters, however, writes us as follows :

“Carbon bisulphide treatment has not always been successful in killing all the weevils in the peas. The amount of carbon bisulphide which I have found to give the best results is one gallon to two carloads of peas, or 450 to 500 bags. (This is a little more than one pound to 100 bushels). It is generally assumed that the treatment in the air-tight chamber, or “bug-house,” for a period of 24 hours will be effectual. Last year, however, having a quantity of peas for shipment to the English market and being desirous of treating them effectually, I placed them in the “bug-house,” and kept them there for nearly a week, and gave them two treatments of carbon bisulphide. After the peas reached England my correspondents there reported that there were still some live weevils in them

I can account for this only on the supposition that at the time of the treatment some of the weevils had not advanced in their development as far as the rest, and that there was less of the inner part of the pea consumed, and that, consequently, the thicker covering protected the weevil from the action of the carbon bisulphide."

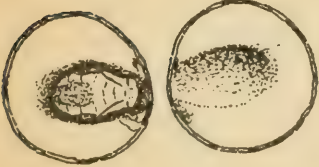
The weevils usually die soon after the laying of the eggs on the young pods, but the exact duration of the life of an adult weevil, so far as we are aware, has never been definitely ascertained. It may be that the weevil lives some weeks after the deposition of the eggs.

A somewhat remarkable occurrence of live weevils in peas is told us by a reliable observer. A shipment of peas was fumigated in Ontario, shipped to England, and stored in a seed ware-house. For some reason or other, these peas were left undisturbed for nearly two years; and in the handling of the peas, a few live weevils were found. This case is, of course, abnormal, and simply means that some weevils may survive after two years of torpor, induced by cold; but it also shows that pea-dealers should be exceedingly careful in their shipments, lest some of the live weevils be carried to new districts.

ESCAPE OF THE WEEVILS. The time of escape of the weevils from the peas is, unfortunately, so variable and irregular, that it may be said with a great deal of truth that they keep on escaping in July, August and September, and from early April to the beginning of June.

It would be a comparatively simple matter to kill the great majority of the weevils with carbon bisulphide, as explained, if they always remained long enough in the peas to allow for the unavoidable delays in harvesting the crop, threshing the peas, and treating the seed. Some of the weevils may escape, however, before the peas are even harvested. The peas grown on the College Farm, in 1901, were threshed in the field with the College separator on the 15th day of August. The pea crop had not been stacked, but was threshed directly from the land and as soon as it was properly cured; and even at that early date, some of the weevils had escaped from the peas. The unevenness in the development of the weevils in the individual peas of the same crop is likely due to the unevenness in the blossoming of the peas in the different parts of the same field, in the individual plants growing side by side, and in the different parts of the same plants. Several repeated examinations have shown that peas grown on even a small plot in the experimental department and fumigated immediately after they were harvested contained weevils in almost every possible stage of development. To illustrate this fact, the Marrowfat variety has been selected. Two hundred average peas grown and treated in each of four years have been carefully examined. In order to represent the results obtained, four stages in the development of the weevils were selected as the basis of classification. The classification, therefore, is represented as follows: 1. Larva, one-eighth grown; 2. Larva, one-half grown; 3. Pupa; and 4. Adult Beetle, escaped. Every weevil in the peas was placed

in the class which it resembled most closely. The following table gives the results of this examination of the development of the weevils at the time they were fumigated.

Stages in the development of the pea weevils at the time of fumigation.		Average percentage of weevils at each stage of development when fumigation took place.				
		1897	1898	1900	1901	Average 4 years.
	Larva ($\frac{1}{8}$ grown)	1	14	7	20	11
	Larva ($\frac{1}{2}$ grown)	2	27	10	25	16
	Pupa	47	59	82	53	60
	Adult escaped	50	..	1	2	13

These results are very suggestive. They throw much light upon the probable effectiveness of the fumigation process in the eradication of the pea weevil. It is owing to the irregularity in the development of the weevil that some of the insects escape so early in the season, while others remain in the peas until a much later date.

In some seasons, the weevils develop and escape much earlier than in others. It is quite probable that the conditions of the weather, such as temperature and moisture, exert an influence on their development. In 1902, the weevils did not escape until much later in the season than usual, evidently owing to the wet, cold summer.

Moreover, it is a matter of common observation throughout the country, that many pods shell their peas in the field while the crop is being harvested. If the peas were pulled just before they ripened, not only would there be less shelled peas on the ground, but the straw would be of much better quality. Hogs turned on the pea stubble would eat a few of the scattered peas and the weevils which they contained. If the peas were stirred into the soil by a cultivator, or turned under with a plow, it is quite probable that some of the weevils would be destroyed by this process.

Weevilly peas which remain in the straw after the crop is threshed, which lodge in the separator to be scattered on the ground, which lie on the threshing floor for several days after threshing, etc., give the weevils an opportunity to escape.

In any effort to destroy the pea weevil, attention must be given to garden peas. Most persons do not realize that when a mess of green peas is eaten, a large number of the grubs of the pea weevil are (to put it mildly) prevented from doing further damage. If all the garden peas were eaten in this way and prevented from ripening, there would be no danger to the general pea crop from such a source. An effort should be made, therefore, neither to allow any garden peas to ripen nor any seeds containing live weevils to be planted.

CARBON BISULPHIDE. Carbon bisulphide is a colorless or slightly yellowish liquid, one-fourth heavier than water. It is extremely *volatile*, i. e., evaporates very rapidly when exposed to the air, and when pure will not injure or stain the finest goods. The commercial liquid has an acrid taste, and an odor like that of rotten eggs. The vapor is more than two and a half times as heavy as air. Carbon bisulphide may be purchased in small quantities from any druggist at about 30 cents per pound, or 40 cents per pint. For larger quantities, better rates can be given by the druggist. The gas, or vapor, which comes from carbon bisulphide is not only combustible, but it is very explosive when mixed with air. Great care should, therefore, be taken to treat the peas in the day-time only, for a light or a flame of any kind brought near the liquid may cause a serious explosion; and smoking near it should be positively prohibited. Moreover, the vapor should not be inhaled, as it is very injurious, even a small portion causing headache, giddiness, and nausea. The treatment with carbon bisulphide should be made in boxes, barrels, or "bug houses," located some distance from the insured buildings on the farm.

With the strict observation of the preceding precautions, no one should hesitate to use the carbon bisulphide. As a matter of fact, we have never heard of any bad results following its use in the treatment of peas. This happy condition of things may be explained when we say that all who used the liquid were wise enough to be

cautious. There is, moreover, no danger that the vapor will injure the peas or render them unsafe as food. Experiments have shown that the liquid can even be poured upon articles of food, and, after thorough exposure to the air, not a trace of it will remain.

FUMIGATION BOX. The fumigation box which has been in use in the Experimental Department for seven years for killing the pea weevil by the carbon bisulphide process is well illustrated by the accompanying diagrams (Fig. 7). The box is rectangular in form,

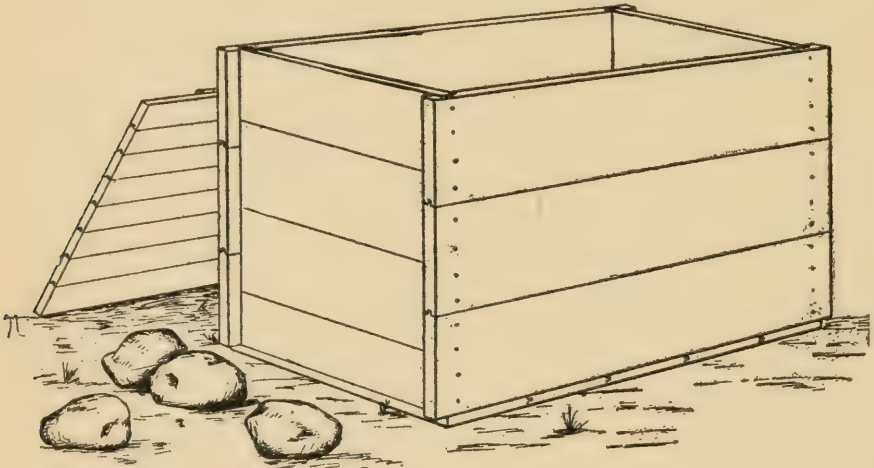


Fig. 7. Fumigation box used in the Experimental Department at the O.A.C. The method of construction is readily seen. (Original.)

being five feet long, two and four-fifths feet wide, and three feet high, and capable of holding about thirty bushels of peas at one time. It is made of pine lumber, $1\frac{1}{2}$ inches thick, tongued and grooved. The end pieces are mortised into the sides. All the joints are made very tight by the use of white lead. The cover is lined with a strip of cloth and is made to fit very closely. This box has been used for the double purpose of fumigating peas to kill the weevils, and of dipping sheep to kill the ticks.

COAL-OIL BARRELS. When a box such as we have described, is not readily made or procurable, one or more *coal-oil barrels* may be used. These are water-tight, and may be covered with a blanket and a close fitting cover, upon which may be placed some heavy stones. Fig. 8 shows the method of using barrels for this purpose. A barrel will hold about five bushels; and for this quantity of peas, three to four ounces of carbon bisulphide are necessary.

This method of treatment is valuable for small quantities of seed peas, but would hardly be adopted when the entire season's crop is to be fumigated, as it would necessitate either a very large number of barrels, or an extended period of fumigation with a few barrels.

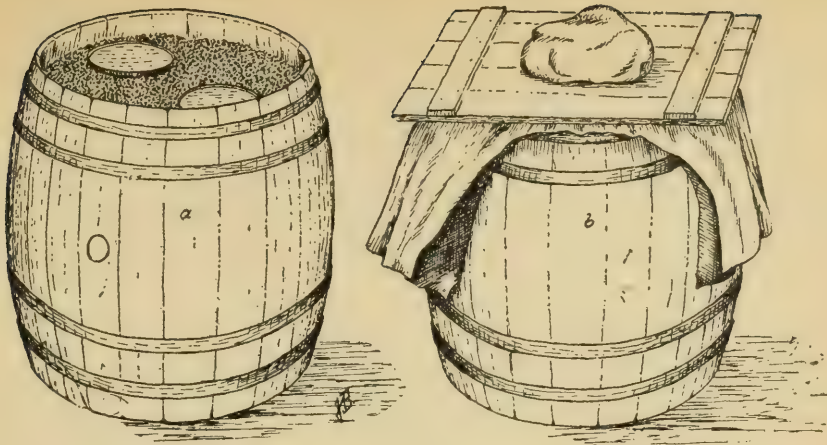


Fig. 8. Method of treating peas in coal-oil barrels. (a) Shows the carbon bisulphide in two pans on the surface of the peas; (b) shows how the peas are fumigated. (Original.)

BUG HOUSES. Many of our large buyers and shippers of peas have specially constructed air-tight chambers, or "bug houses," in which several hundreds of bags of peas are treated at one time with carbon bisulphide. In some cases, farmers, especially when the pea crop is large, could profitably erect "bug-houses." It is not necessary in all instances to construct a separate building for this purpose. It would be more economical for the farmer to build a compartment in his barn, as it would make tight, clean storage for grain, robes, blankets, or other articles, during the portion of the year when it is not used for treating peas.

This may affect insu

A chamber 12 feet long, 6 feet wide, and 8 feet high is about the right size for treating the season's crop. Besides the siding on the outside of the frame, there should be two thicknesses of dry tongued-and-grooved matched lumber, with building paper between, well nailed on the outside of the frame. The ceiling should also be made in a similar manner. The beams and joists of the building should be so rigid that they will not give in the least when loaded, lest a crack be made in the side, and allow the gas to escape. The floor should be made of two thicknesses of sound, matched, tongued-and-grooved lumber, with building paper between the thicknesses.

The door-way should have two doors, an inner one not on hinges, but have two handles with which to lift it and put it in place, and an outer one which is hinged. Both of these doors should fit against rubber or felt strips laid on grooves cut in the door-frame. The doors can be wedged tight against the rubber padding by means of three oaken cross bars (at the bottom, middle, and top) which can be driven like wedges into slots cut in the door-casing. (See Fig. 9.)

Other Methods of Treating Peas. The method of *holding over* peas in closed bags or tight boxes for a year is one which has been in operation for many years. The weevils which escape from the

seed soon die, and are not able to lay their eggs in the field. This method is only partially effective, since many weevils make their escape before they can be bagged.

The *boiling water* treatment has also been used for many years. The infested seed is thrown into boiling water for one minute, then quickly removed. This method has never been widely adopted, since the germ is very apt to be injured by longer immersion than one minute in the boiling water.

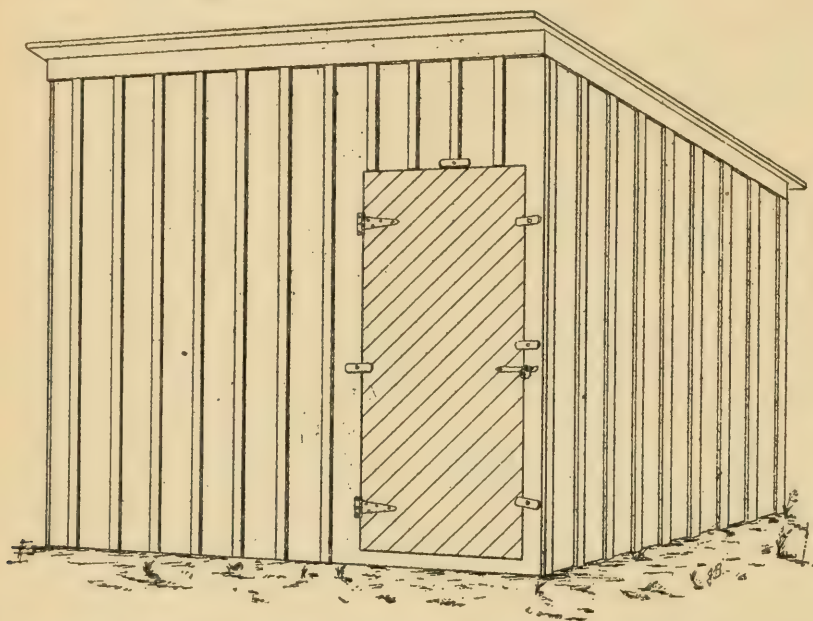


Fig. 9. Fumigation house at the Ontario Agricultural College. There are two doors, one in front and the other in the rear, to facilitate ventilation; the door is driven up tightly against the felted casement by means of large wooden buttons. (Original.)

Infested peas may be treated successfully by *heating* them to a temperature of 145° F. without injury to the germ, but this method has never been widely adopted, for obvious reasons.

Although we have never tried the *coal oil treatment*, some of our correspondents report successful results, and outline the process as here described: The peas are spread on the barn floor in a thin layer about six inches deep; and the oil is sprinkled over the seed through a machine oil-can. Then the peas are turned over very thoroughly so that every pea becomes coated with a thin film of oil. In this condition the peas are left for two or three days, when it will be found that the weevils have been killed. One quart of oil is sufficient for twenty bushels of peas.

This method is to be recommended in the treatment of small quantities, such as seed peas; but we are of the opinion that it would not be a practicable method for treating peas in large quantities immediately after harvest.

5147
ONTARIO AGRICULTURAL COLLEGE.

BULLETIN 127.

FARM POULTRY

WITH THE RESULTS OF SOME EXPERIMENTS IN

FATTENING CHICKENS,

BY

W. R. GRAHAM, B.S.A.,
POULTRY MANAGER AND LECTURER.

PUBLISHED BY THE ONTARIO DEPARTMENT OF AGRICULTURE,
TORONTO, ONTARIO, MAY, 1903.

PRINTED BY L. K. CAMERON,
Printer to the King's Most Excellent Majesty.

THE ONTARIO AGRICULTURAL COLLEGE

AND

EXPERIMENTAL FARM

GUELPH, ONT.

HON. JOHN DRYDEN, Minister of Agriculture,
Toronto, Ont.

STAFF OF PROFESSORS AND INSTRUCTORS.

JAMES MILLS, M.A., LL.D.	President
H. H. DEAN, B.S.A.	Professor of Dairy Husbandry
C. A. ZAVITZ, B.S.A.	Director of Field Experiments
J. HUGO REED, V.S.	Professor of Veterinary Science
G. E. DAY, B.S.A.	Professor of Agriculture and Farm Superintendent
H. L. HUTT, B.S.A.	Professor of Horticulture
J. B. REYNOLDS, B.A.	Professor of Physics and Lecturer in English
F. C. HARRISON, B.S.A., D.P.H.	Professor of Bacteriology
W. LOCHHEAD, B.A., M.S.	Professor of Biology and Geology
R. HARCOURT, B.S.A.	Professor of Chemistry
W. R. GRAHAM, B.S.A.	Manager and Lecturer in Poultry Department
H. R. ROWSOME	Lecturer in Apiculture
M. W. DOHERTY, B.S.A., M.A.	Associate Professor of Biology
W. P. GAMBLE, B.S.A.	Associate Professor of Chemistry
M. CUMMING, B.A., B.S.A.	Associate Professor of Agriculture
W. J. RUTHERFORD	Dean of Residence and Instructor in English and Mathematics
H. STREIT, D.M.V.	Assistant in Bacteriology
W. C. GOOD, B.A.	Assistant in Chemistry
ALICE ROWSOME, B.A.	Assistant in Library and Instructor in French and German
T. D. JARVIS, B.S.A.	Fellow in Biology
G. B. MCCALLA, B.S.A.	Fellow in Physics
CAPTAIN CLARK	Instructor in Drill and Gymnastics

OFFICE STAFF.

S. SPRINGER	Bursar
B. S. PICKETT	Secretary
ANNIE HALLET	Stenographer
F. K. DOUGHERTY	Departmental Stenographer
W. O. STEWART, M.D.	Physician

Ontario Agricultural College and Experimental Farm.

FARM POULTRY, WITH THE RESULTS OF SOME EXPERIMENTS IN FATTENING CHICKENS.

BY W. R. GRAHAM, B.S.A., POULTRY MANAGER AND LECTURER.

This Bulletin is intended to give information to farmers and others, on general matters pertaining to the keeping of poultry.

It also contains the results of a few experiments which have been conducted at this institution in fattening chickens for the home and export market.

CONSTRUCTION OF POULTRY HOUSES.

We find poultry thriving and yielding good returns in so many different styles of houses, that it is very difficult to lay down any hard and fast rules. The tendency at present is towards cheaper houses, with better ventilation. The hot-house style of housing poultry during the winter has not been satisfactory, many of the houses being damp, and the air in them anything but agreeable. Disease has been quite common; and the results in many cases have been disappointing. To the plans given below, there are no doubt some objections; but there are strong points in each. Many of these houses are giving excellent results in Ontario.

Every poultry house should be light; at least one-third of the south side of it should be of glass, or otherwise opened to the sun. It should face the south-east or south. The sun's rays are very beneficial to fowl, especially during the winter months.

POULTRY HOUSE OF L. H. BALDWIN, DEER PARK (TORONTO).

Mr. L. H. Baldwin's poultry house is a good one. It is well planned and has given good results. I have always found Mr. Baldwin's fowls very healthy and in good laying condition. The point of excellence in this plan of a house is that the fowls are allowed exercise in the open air, and are, at the same time, protected from the wind. It also furnishes a warm roosting pen.

After a very full inspection of several hen-houses erected on many of the leading poultry farms of the Eastern States, Mr. Baldwin decided to build a hen-house on the scratching-shed plan. He came to the conclusion that this plan was best suited for a climate such as they have in Toronto.

His hen-house is a frame building 72 feet long and 10 feet deep, and is divided into four scratching-sheds and four hen-houses proper. The ground plan is shown in Fig. 1. The sills are 4x4 cedars, resting on large stones. The end sill rests on stone, and the sill running the length of the building rests on top of the end sill. The studding used is 2x4 hemlock. The top of the sill is one foot above the surface of the ground, and a base-board is fastened on the inside of the sill, and the floor of the hen-house is filled with sand to the top of the base-board. The building is banked up on the outside to the same level. The stones upon which the sills rest are placed at varying distances to meet the joists and at intervals of about 8 feet. The north wall is 4 feet high from the top of the sill, and the south wall 7 feet high. In the north wall, the studding is placed at each corner of the hen-house proper and an additional one in each centre, also at the corner of each scratching-shed, and an additional one in the centre. In the south wall the studding is placed in the same way, excepting the one in the centre of the hen-house, which is placed so as to accommodate the window. At the east end, an extra stud stands as a door post; and one at the west end, in the centre. For rafters, he used 2x4 hemlock, placed at 2 feet centres. On the outside of the studding and rafters he used the most ordinary lumber, running the boards lengthwise. The ends of the building, the north wall, and the south fronts of the hen-house proper are covered with a two-ply "ready roofing;" and for the roof he used three-ply "ready roofing." A scantling 2x4 reaches from the north sill to the south sill at the base of each division between scratching pens and hen-houses proper, and between the hen-houses. The division wall between the scratching-shed and the hen-house is made of rough lumber on the scratching-shed side with a lining of tar felt nailed on the interior of these boards, and battened closely with laths to make the joints of the tar felt complete. The division wall between the hen-houses proper is made of 7x8 tongued and grooved flooring, and the other interior walls of the hen-houses proper, that is, the walls against the scratching-sheds and the north and south walls, are lined with 7x8 tongued and grooved dressed material. The ceiling is also completed in the same way. But before the putting on of this dressed material, a second layer of tar felt was placed between the sheeting and rafters, so that there is a dead-air space. The large doors between the scratching-sheds and the hen-houses proper are about three inches thick, made of two thicknesses of 7x8 tongued and grooved dressed material, with a space of one inch between, and lined with tar felt on the inside of each

thickness. These doors are raised a foot above the level of the sills, and in this space near the south wall is cut small doors for the poultry, 10 inches wide, having sliding doors.

Interior Arrangements.

The dropping board is three feet wide and 18 inches above the level of the top of the sills. Two roosts, each 2x3, are placed on the

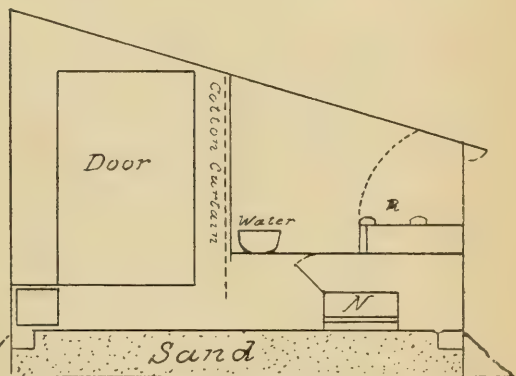
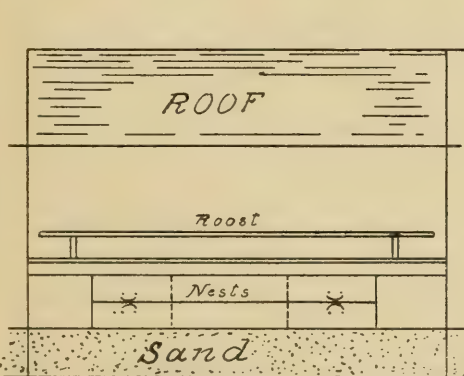
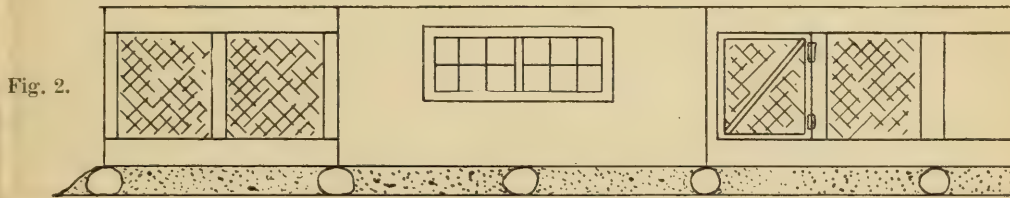
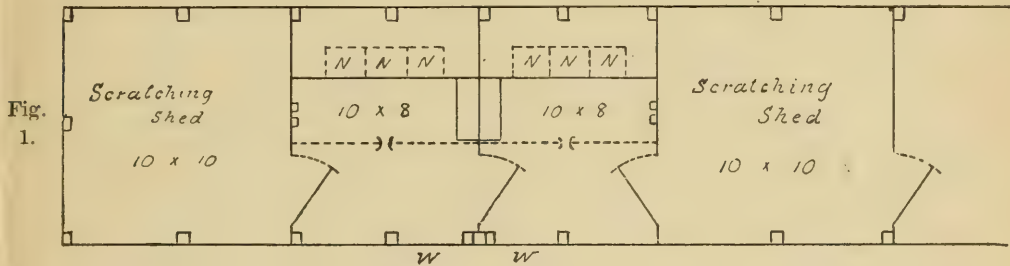


Fig. 3.

Fig. 4.

POULTRY HOUSE OF L. H. BALDWIN, DEER PARK.

Fig. 1. Ground plan of one half of the house. Fig. 2. Front elevation. Fig. 3. Cross section of a single pen from east to west. Fig. 4. Cross section of a single pen from north to south.

flat side, fastened together by a cross strip which is hinged to the north wall. Two legs support the roosts on the outer side. The roosts being hinged, they can be lifted up and fastened to the roof so as to leave a clear space when making the daily cleaning. The roosts come short of each pen by about two inches. Three nests are allowed to each pen. These are each 18 inches square, having the ends solid. The nests are placed under the dropping board facing the north wall, rest on the sand, and can be taken out for cleaning. The

back of the nest is made in two pieces. The upper part is fastened to the lower board by spring hinges, which enables one in collecting eggs to reach the nest conveniently ; and the spring hinges make the top board fly back into place. Against the inside division between the hen-houses proper, a 12 inch board extends on the level of the dropping board to within 12 inches of the door, and an upright 12 inch board is fastened to the end of this and runs up to the ceiling. To correspond with it, a board is placed against the opposite wall, and a cotton curtain on a two inch roller is fastened to the ceiling. This curtain is shown by the dotted lines across pens in Fig. 4 and at x in Fig. 1. When this curtain is down it comes to the bottom of the two last mentioned upright boards that is to about 2 inches below the level of the dropping board. The purpose of this curtain is to protect the fowls on very cold nights. Mr. Baldwin has found that it is not necessary to use it when the pens contain over 15 birds ; but if the number is reduced, and the thermometer drops to the neighborhood of zero, it is well to let it down.

Plenty of Light.

The windows in front of the hen-houses proper are each three feet wide and two feet 6 inches high, containing 6 panes, 10x12 inches each. The windows are placed high in the front wall and slide to the right and left. The windows being placed high up, the sun in winter, when it is low in the heavens, shines on to the roost and dropping board. The door between the hen-houses proper, which is also a foot above the level of the sills, is a simple door of 7x8 inch stuff, the upper half being made of wire netting. The front of each scratching shed is divided in two by the centre studding, on each side of which there are cotton screens hinged at the top, and reaching down to within one foot of the top of the sill ; and, when down, close upon top of a rainboard which slopes to the outside, so that rain beating against the cotton screen is carried outside ; and this keeps the interior dry. These screens swing up to the roof, and are there caught by hooks from the rafters. The front of each scratching-shed is closed with two-inch mesh wire netting. (One-inch mesh should have been used to keep out the sparrows, which now get in and run off with a lot of grain). An eaves-trough runs the length of the building, distributing the water east and west. Drinking fountains are placed on the end of the board that runs out from the dropping board ; and on the wall opposite thereto the boxes for grit and oyster shells are hung.

Sanitary Precautions.

The interior of the hen-houses and the scratching-sheds is filled with sand to the level of the top of the sill ; and on top of this a

plentiful supply of loose straw is kept, to encourage the birds to scratch and thereby get exercise. In August the straw is all cleaned out ; and the sand, so far as it appears to be soiled, say, to a depth of four or five inches, is all taken out, and fresh sand put in its place. It is advisable to do this in August, so that the sand may become perfectly dry before the winter sets in. No straw is placed on top of the sand until the time comes to close the birds up for the winter. The windows of the hen-house proper are open every day. Of course, when the weather is stormy or bitterly cold they are open only for 15 minutes or half an hour in the middle of the day. When the sun is shining brightly they may be left open for some hours. This thoroughly ventilates the hen-houses, dries up all moisture, and keeps the place clean and sweet. The screen in front of the scratching-shed is let down only on very cold days, and when the weather is cold and stormy, the idea being to keep the open shed dry where the birds take exercise in the open air.

This method of housing poultry keeps the stock in the most vigorous health ; and this is the secret of Mr. Baldwin's success in obtaining a plentiful supply of fertile eggs. He began incubating in January last, and out of 1,100 White Wyandotte eggs set during the season he obtained 66 per cent. of chicks. The runs of his hen-houses extend to the north and west of his buildings, as it best suits the shape of his lot. The runs are in most cases placed to the south of the building ; and sometimes, where it is possible, they are extended north and south, and are used alternately. From the practical experience of five years' use of the building, Mr. Baldwin's opinion is that it is well adapted in this section of the country for keeping breeding stock and maintaining it in most vigorous health, which is the foundation of success. He keeps only White Wyandottes, and thinks that the building would, perhaps, be too cold for the more delicate breeds, although he at one time kept White Leghorns in it with considerable success. In one phenomenal hatch of Leghorn eggs he secured 95 chicks from 95 fertile eggs, out of a total setting of 100 eggs. This affords some idea of the vigor of the stock, and the fertility of the eggs secured from birds kept in hen-houses erected on this plan. Mr. Baldwin believes that many who have adopted the scratching-shed hen house have adjusted windows to the front of the scratching-shed in place of the screen ; and this might be an advantage, especially in sections of the country where the weather is more severe than in Toronto.

Cost of the Building.

He estimates the cost of his building at \$250, allowing for his own time ; but on account of the increased cost of lumber and labor, a similar building would now cost about \$300. The cost, of course, depends upon the facilities for obtaining material and labor. He

keeps about 18 hens in each pen during the winter, and obtains a plentiful supply of eggs.

THE POULTRY HOUSES AT O. A. C.

The Colony House in use at this College is more or less of an experiment, but it is cheaply constructed, and allows a warm roosting pen and exercise in the open air. The canvas door protects the fowls

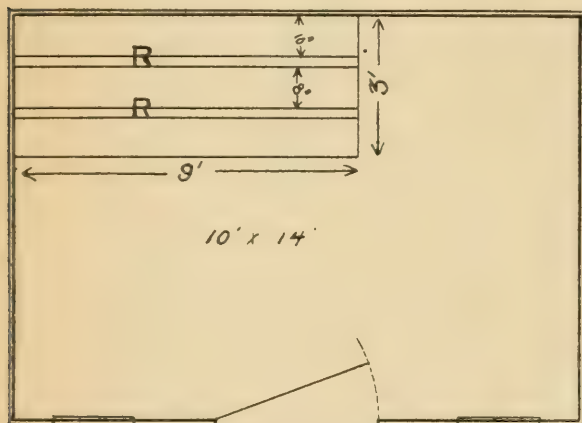


Fig. 5.—Ground plan of colony house at O.A.C.

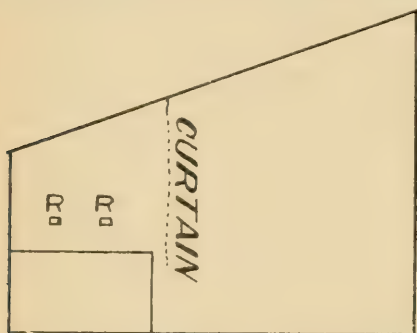


Fig. 6.—Cross section of colony house.
R, R, roosts.

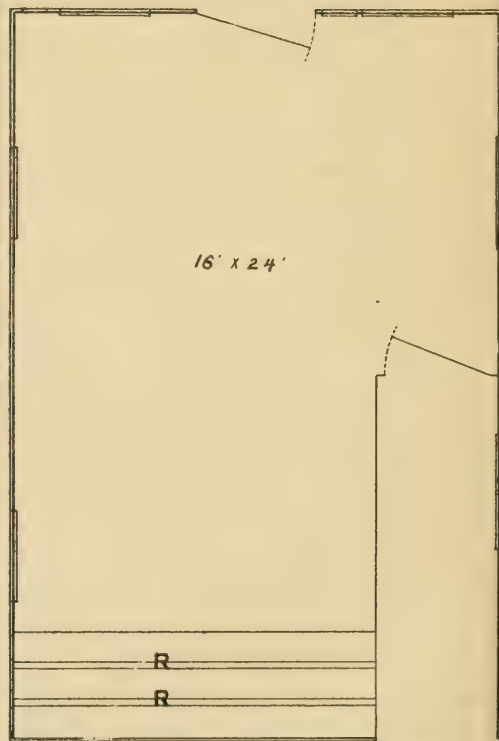


Fig. 7.—Ground plan of closed pen.
R, R, roosts.

from the extremely cold winds. In very severe weather the board door in front of the house may be shut.

This house is made of a single thickness of planed lumber, the cracks between boards being covered by battens. It is not sheeted on the inside, except in the roosting compartment, which is lined with paper and matched lumber. We wintered Plymouth and Wyandotte fowls successfully in this coop before the roosting compartment was put in. It was, however, so cold at night time, in very severe weather, that egg production was practically stopped for a day or two. I would not recommend its use where Leghorns or such birds are to be kept. This house will accommodate from 20 to 25 chickens.

The plan of the closed house in use at this College (see Figs. 7 and 8) is designed to admit of exercising the fowls in the open

air, to have a constant supply of fresh air, and a warm roosting pen. Formerly, this house was equipped with double doors, walls, and windows; it was as tight as a drum, and there was a constant dampness during the winter, owing largely to a lack of fresh air.

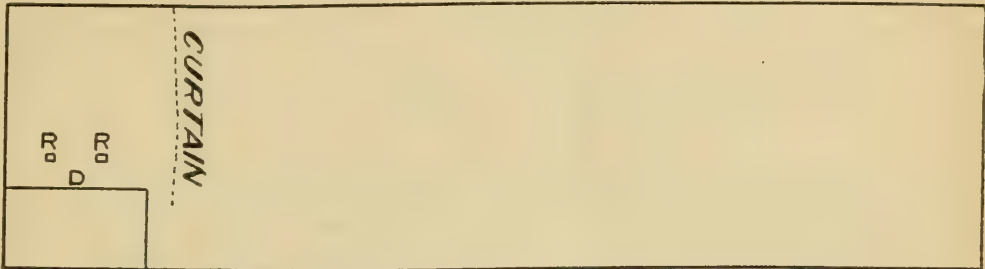


Fig. 8.—Crossed section of closed pen. R, R, roosts; D, dropping board.

The substitution of a curtain for the door on the south side will, we are satisfied, admit abundance of air and do away with the dampness. This house will accommodate from 40 to 50 fowls.

GENERAL RULES FOR BUILDING.

Every hen should be allowed at least 6 square feet of space in the scratching pen, and about 4 square feet in the roosting pen. Each bird of the Plymouth Rock, Wyandotte, and such breeds, requires about 9 inches of perch room; Leghorns, etc., about 8 inches; and Brahmas, 10 inches.

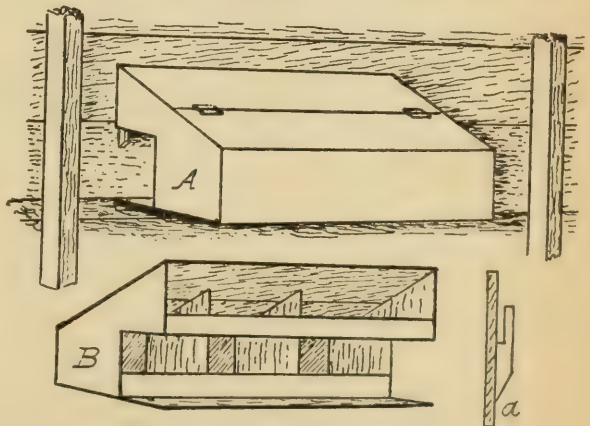
Roosts should be made low, or near the ground. There are several reasons for this. Fowls of the heavier breeds cannot fly high, and those of the lighter breeds frequently injure the soles of their feet in jumping from high perches.

When dropping boards are used, they should be moderately low down, to admit of easy cleaning. Dropping boards should be made of matched lumber, and should be 20 inches wide for one roost, and three feet for two perches, the first being placed eight to ten inches from the wall.

Most poultry men prefer roosts 2 inches by 2 inches, with edges slightly rounded.

Nests. Many use only old boxes; but such nests, if near the ground, are apt to induce egg-eating. Dark nests prevent this. (Figs. 9 and 10.)

Nests are usually made from 12 to 15 inches square.



Figs. 9 and 10. Front and back views of nests.
(Poultry Craft.)

Ground floors are more in favor than board floors, and cost much less.

In my own experience, the best results are obtained from keeping 20 to 25 birds in a flock. Some succeed with 60 to 75 in a flock; but these are the minority.

BREEDS OF POULTRY.

Plymouth Rocks. There are three varieties of this breed, viz., Barred Plymouth Rocks, White Plymouth Rocks and Buff Plymouth Rocks. The Barred variety is the oldest and most popular, owing to its having been introduced some years previous to the last two named varieties.

The same general characteristics apply to the three varieties. They are fairly hardy, good winter layers, fair summer layers, lay brown eggs, make fair mothers, are sitters, have naturally yellow legs and flesh, have single combs, and are all-round good general purpose fowl.

The standard weights are: Cock, $9\frac{1}{2}$ lbs.; cockerel, 8 lbs.; hen, $7\frac{1}{2}$ lbs., and pullet, $6\frac{1}{2}$ lbs.

Wyandottes. There are several varieties of this breed, viz., White, Black, Buff, Silver-Laced, Golden-Laced, Partridge, and Silver-Pencilled.

The last two varieties are comparatively new, and are not at present nearly so plentiful as are the other varieties.

The White Wyandotte is bred by many market poultrymen, and is very popular.

This breed, in its different varieties, possesses the same general characteristics as the Rocks, with the exception that they have a rose-comb and are more blocky in appearance.

The standard weights are: Cock, $8\frac{1}{2}$ lbs.; cockerel, $7\frac{1}{2}$ lbs.; hen, $6\frac{1}{2}$ lbs., and pullet, $5\frac{1}{2}$ lbs.

Rhode Island Reds. This breed is bred extensively by the farmers in the State of Rhode Island, where it originated. It has not as yet been admitted to the American standard of perfection. Hence we have no official description of the breed, except that given by the Rhode-Island-Red Club.

They are said to be fairly hardy, fair winter and summer layers, are setters, only fair mothers, brown egg breed, have yellow legs and skin and mature early. They are a reddish buff in color, with a strong tendency to black colored tails and wings; also black ticking in the hackle feathers.

The R.I.R. Club gives the following weights: Cock, 7 lbs.; cockerel, 6 lbs.; hen, $5\frac{1}{2}$ lbs., and pullet, $4\frac{1}{2}$ lbs.

Orpingtons. There are three varieties of this breed, viz., Black, White, and Buff Orpingtons. The Buff variety is far more popular than the other two. Buff Orpingtons seem to be well adapted to this country, and have the color of flesh sought after in the British market. They will certainly be great rivals of the Rocks and Wyandottes as the farmers' fowl.

They are fairly hardy, good winter layers, brown egg breed, are setters, good mothers, have white legs, white skin, and usually have single combs. There are a few rose-comb Buffs, but they are rather scarce.

Standard weights: Cock, $10\frac{1}{2}$ lbs; hen, $8\frac{1}{2}$ lbs.; cockerel, 9 lbs., and pullet, 7 lbs.

In breeding this variety, where market chickens are wanted, I would prefer birds of at least one pound less in weight than the standard weight given.

Leghorns. There are several varieties of Leghorns. The most popular are the Single-Comb White, Brown, Buff, and Black. The Rose-Comb White and Brown are also bred to some extent.

All Leghorns are considered to be non-sitters. An occasional one shows some inclination to sit, but these are not to be relied upon. They are excellent layers, especially during the summer months. The eggs are white in color. As a rule, the Single-Comb White lays a larger egg than the other varieties.

Leghorns require a fairly warm house on account of the size of their comb, particularly the male bird. These birds are fairly hardy and vigorous. They are too small for table use, unless as broilers.

Minorcas. The Single-Comb Black is the most popular variety. The Rose-Comb Black and Single-Comb White are not so generally bred. This breed is larger than the Leghorn or Andalusian. They lay very large white eggs. They are a good summer layers and are usually non-sitters. Their very large combs are an objection in cold climates. These fowls are fairly hardy and vigorous.

Standard weight: Cock, 8 lbs.; hen, $6\frac{1}{2}$ lbs.; cockerel, $6\frac{1}{2}$ lbs.; pullet, $5\frac{1}{2}$ lbs.

Blue Andalusians. This breed is midway in size between the Minorca and Leghorn, and generally non-sitters, and lay a large white egg. They are splendid summer layers. The chief objection to them is that they do not breed true to color, the chicks coming blue, black, and nearly white. There are usually about 50 per cent. blue chicks. The size of their combs is also considered an objection in a cold climate. They are fairly hardy and vigorous.

Standard weight: Cock, $6\frac{1}{2}$ lbs.; hen, $5\frac{1}{2}$ lbs.; cockerel, $5\frac{1}{2}$ lbs.; pullet, $4\frac{1}{2}$ lbs.

Games. The Indian Game is the chief variety of interest to the farmer. They are a good market fowl, having a splendid development of breast meat; but their breast is considered by some to be

rather short. They are fairly hardy, but are only moderate layers of medium-sized brown eggs. They are good sitters and mothers. Crossed with Dorkings, Rocks, or Wyandottes, they make excellent fowls for the market. These crosses are, however, seldom good layers.

Standard weight: Cock, 9 lbs ; hen, $6\frac{1}{2}$ lbs.; cockerel, $7\frac{1}{2}$ lbs.; pullet, $5\frac{1}{2}$ lbs.

Dorkings. There are several varieties of this breed, the most popular being the Silver Grey and colored varieties. Birds of this breed are among the best market fowls yet produced, and they are fair layers of good-sized, white eggs. They are fair sitters and mothers. They have white legs, white skin, and five toes.

The fault of this breed in Ontario is that they do not do well in confinement, and are not considered hardy. With some farmers, however, they are very popular.

Standard weight of Silver Grey variety: Cock, 8 lbs.; hen, $6\frac{1}{2}$ lbs.; cockerel, 7 lbs.; pullet, $5\frac{1}{2}$ lbs.

EGG PRODUCTION.

To produce eggs in winter time, we have to consider the stock, the quarters or housing, the feed, and the weather.

Stock. The stock needs to be the best obtainable. An ideal bird for winter egg production is a pullet that is mature at about Nov. 1st, and is strong and vigorous, and of a good laying strain. Something depends upon the breed, but more on the strain of the breed; also much upon a good strong constitution, and an abundance of vigor. These are the essential points.

To get pullets of such birds as Rocks, Wyandottes and Orpingtons matured by November, it is necessary to hatch them in April. Some seasons May chicks mature quickly and begin laying about the first of December, but not as a rule. If a pullet does not commence to lay before Christmas, it is doubtful if she will begin much before March, unless the weather is favorable. Then again, good yearling hens that have moulted early are likely layers. The problem, how to get hens to moult early, is not entirely solved as yet. No doubt it has been noticed that hens which sit and bring out a brood of chicks from June 10th to July, usually moult about the time they are leaving their chicks. Some hens that sit earlier also moult early; but as a rule they begin to lay after sitting, and are rather inclined to late moulting.

From the above, it would appear that the best method to get the flock in general to moult would be to place the flock under conditions similar to those of the sitting hen. This is done by some egg-farmers with more or less success. The plan followed is to change the hens to

a new, free range about July 1st, and feed but very lightly, not more than one handful of grain to each hen daily. The object is to induce the hens to dine largely on grass and water, and *stop egg production*. After being thus treated for from two to three weeks, the hens are again well fed on a good laying ration. In many cases they begin to moult; and, if fed well, get their new coat of feathers in quickly, and thereby save time. I have had a few hens which have begun to lay heavily as soon as I have started to feed them well; but this is not very often the case.

Hens over two years of age are seldom good layers. Leghorns Minorcas, etc., are sometimes good during their third and fourth years; but, generally speaking, the Rocks and such fowls are of little or no use as layers after the second year, being much inclined to become excessively fat.

For *summer egg production* the lighter breeds and late-hatched pullets of the heavier breeds are best. Do not expect a hen that has laid well all winter to lay exceptionally well during the summer. A hen that lays early is inclined to show a desire to sit early in the season. The following tables show plainly that eggs can be produced at a profit during the summer, even where all the grain has to be bought.

EGG-PRODUCTION AT THE O. A. C. IN 1901.

April 22 to May 22nd. Rocks—13 hens, 1 cock:

Mixed feed—17.687 lbs., at \$1.33 per cwt.....	23 526 cents.
Bone—16.687 lbs., at \$1.00 per cwt	16 687 "
Mash—32.375 lbs., at 90c. per cwt.....	29 137 "
Wheat—21.875 lbs., at \$1.13 per cwt.....	24.71 "
Milk—32 lbs., at 10c. per cwt	3.20 "
Total	97.26 "

Eggs laid, 16 dozen; cost per dozen, 6.06 cents.

Nearly all Rocks were broody during last week.

April 22nd to May 22nd. Andalusians—13 hens, 1 cock:

Mixed cracked grain—14.3 lbs., at \$1.33 per cwt	19 01 cents.
Green bone—13.75 lbs., at \$1.00 per cwt	13.75 "
Mash—35 lbs., at 90c. per cwt.....	31.50 "
Wheat—24 lbs., at \$1.33 per cwt., or 68c. per bushel ...	31.92 "
Milk—35 lbs., at 10c. per cwt	3.5 "
Total	99.68 "

Eggs laid, 20½ dozen; cost per dozen, 4.86 cents.

May 22nd to June 22nd—Barred Rocks:

Oats—2 lbs. 8 ozs., at \$1.00 per cwt	2.5 cents.
Bone—2 lbs., at \$1.00 per cwt.....	2. "
Mash—40 lbs., at 90c. per cwt.....	36. "
Milk—40 lbs., at 10c. per cwt.....	4. "
Wheat—34.8 lbs., at \$1.13 per cwt	39.32 "
Total	83.82 "

Eggs laid, 13 dozen and 10 eggs; cost per dozen, 6.15 cents.

May 22nd to June 22nd. Andalusians:

Milk—40 lbs., at 10c. per cwt.....	4.	cents.
Oats—3 lbs., at \$1.00 per cwt ...	3.	"
Wheat—35.437 lbs. at \$1.13 per cwt	40.04	"
Mash—40 lbs., at 90c. per cwt.....	36.	"
Bone—11.375 lbs., at \$1.00 per cwt	11.37	"

Total 94 41 "

Eggs laid, 18 dozen and 2 ; cost per dozen, 5.06 cents.

June 22nd to July 22nd. Barred Rocks:

Wheat—26.375 lbs., at \$1.13 per cwt	29.80	cents.
Oats—6.25 lbs., at \$1.00 per cwt.....	6.25	"
Mash—41.75 lbs., at 90c. per cwt.....	37.57	"
Milk—41 lbs., at 10c. per cwt	4.1	"
Bone—1 lb., at \$1.00 per cwt.....	1.00	"

Total 78.72 "

Eggs laid, 13 dozen and 10 ; cost per dozen, 5.69 cents.

June 22nd to July 22nd. Andalusians:

Wheat—35.625 lbs., at \$1.13 per cwt.....	40.25	cents.
Oats—6.25 'bs., at \$1.00 per cwt.....	6.25	"
Mash—40 lbs., at 90c. per cwt	36.00	"
Milk—40 lbs., at 10c per cwt.....	4.00	"
Bone—1 lb., at \$1.00 per cwt.....	1.00	"

Total cost..... 87.50 "

Eggs laid, 16 dozen and 1 ; cost per dozen, 5.44 cents.

July 22nd to August 22nd. Barred Rocks:

Wheat—32.625 lbs., at \$1.13 per cwt	36.86	cents.
Oats—9 lbs., at \$1.00 per cwt.....	9.00	"
Mash—35.9 lbs., at 90c. per cwt.....	32.31	"
Milk—40 lbs., at 10c. per cwt	4.00	"
Bone—2 lbs., at \$1.00 per cwt.....	2.00	"

Total cost..... 84.17 "

Eggs laid, 14 dozen and 1 ; cost per dozen, 6.2 cents.

July 22nd to August 22nd. Andalusians:

Wheat—27.25 lbs., at \$1.13 per cwt.....	30.79	cents.
Oats—14.875 lbs., at \$1.00 per cwt.....	14.875	"
Mash—40.5 lbs., at 90c. per cwt.....	36.45	"
Milk—40 lbs., at 10c. per cwt.....	4.00	"
Bone—3 lbs., at \$1.00 per cwt.....	3.00	"

Total cost..... 89.115 "

Eggs laid, 14 dozen and 9 ; cost per dozen, 6 cents.

Average cost per dozen for Rocks, 6.02 cents per dozen.

Average cost per dozen for Andalusians, 5.34 cents per dozen.

HOUSING. The housing of fowl was discussed in a previous paragraph. It is well to remember, however, that the house should be clean, the droppings being removed at least twice a week ; it should also be well aired and kept dry, to avoid dampness and foul, stagnant air.

FEEDS AND FEEDING. The main points to be considered in feeding are, that there be a good supply of green food, meat food, and grain, the latter both ground and whole. It is also necessary to feed so as to induce birds to take exercise. In winter green food is supplied by feeding cabbage, turnips, or other roots, pulped or whole, and by

feeding steamed cut clover or clover leaves in the mash. Meat food is supplied in the form of ground green bone, cooked offal, such as beef heads, etc., and in the form of animal meal. In Ontario the ground bone is perhaps the best and cheapest, where one has a bone mill; where not, beef heads, livers, etc., give good results. Animal meal, dried blood, etc., are good foods, but in many cases are more expensive than the others mentioned. However, they are very useful during the hot weather, when it is almost impossible to use fresh meat. Partially decayed meat *should not be used*, as it is not healthful.

Wheat is undoubtedly the most popular grain food for fowl in Ontario. It is certainly a good food, and is very much relished by poultry.

Corn is not used so much in Ontario as in New England States. There it appears to be used quite freely in both summer and winter feeding of fowls. It is used whole, ground, and cracked, the meal being used principally in the mash foods. Cracked corn is used largely for young chicks and fowls when scattered in the litter. The whole corn is rather large and conspicuous; and, when in the litter, does not give enough exercise. I am of the opinion that corn can be used in portions of Ontario, where it is grown extensively, much more freely than it has been heretofore. Corn is a heating and fattening food, and is therefore best adapted for winter use. It is considered by many, when fed in large quantity, to make the hens fat; yet it is used extensively by many progressive poultrymen with little or no evil effects.

Oats should be a first-class food for poultry; but, owing to the large percentage of hull, they are not relished by chickens, and for this reason they are somewhat indigestible. When ground they are used pretty freely in mash food; also the rolled and granulated oat-meals are used for feeding young chicks. The ground oat, without the hull, is used extensively for fattening fowl.

Barley, either whole or ground, is very good. It has rather too much hull; but otherwise it is a satisfactory food. It is considered by many to be next to wheat in point of value.

Buckwheat is very popular as an egg-producer, in districts where it is grown extensively. Some difficulty is at times experienced when first feeding it to fowls in getting them to eat it, but this is usually overcome in a day or so, if other feeds are withheld. Boiling the buckwheat will sometimes start the birds to eat it. After the birds once get accustomed to its appearance, it is much relished by them. Ground buckwheat is an excellent food to use in a fattening ration. It is somewhat like corn in its fattening properties and therefore it is better for winter than summer use.

Shorts and wheat bran are both used extensively in making mashes, or soft foods. They are excellent foods to use in maintaining the health of the flock.

The general method of feeding is to give a mash of mixed ground grains, moistened with water or milk, in the morning; a little whole grain scattered in the straw covering the floor, at noon; and all the whole grain they will eat at night. This latter meal is usually fed in the straw. Some poultrymen adopt the plan of not feeding the mash until evening. We have been practising this plan for some time, and we like it very well. The objection to the former plan is that the hen is likely to become gorged with food early in the morning, and thus take to the roost for the rest of the day, which is usually followed by hens becoming too fat, and the egg record becoming small; but notwithstanding, many successful poultrymen use this method to advantage. The objection to feeding the mash at night is that it becomes quickly digested, and the bird has not sufficient food to last it during the long winter night; but this objection can be overcome by giving a little whole grain after the mash at night.

Some poultrymen feed their fowls but twice a day, morning and evening, and get very good results; but I favor feeding three times a day. Our plan is somewhat as follows:

Early in the morning the fowls are given half a handful each of whole grain. This is buried in the litter on the floor. Thus the fowls get exercise (a very necessary thing) in searching for it and at the same time keep themselves warm. At noon about two handfuls of grain are given to a dozen hens in the litter; they are also given all the roots they will eat, either pulped or whole, as fowl relish mangels, sugar beets and turnips. Cabbage also—a very good green food—is sometimes given. About four o'clock in the afternoon they are fed a mash composed of equal parts of bran, shorts, oat-chop and corn-meal (during cold weather); and to this is added about 10 per cent. of animal meal, if we have not cut, green bone or cooked meat. These foods are thoroughly mixed together in the dry state, after which is added steeped clover, which has been prepared by getting a bucket of clover leaves, or cut clover hay, and scalding it with boiling water. This is done early in the morning, and the bucket is kept covered with a thick sack throughout the day. This will be quite warm at night if it has been kept in a warm place. There is usually sufficient liquid to moisten the meal that has been mixed. Our aim is to have about one-third of the ration, in bulk, of clover. After the mash a small amount of whole grain is fed in the straw. There is—and should be—a plentiful supply of good, pure water within easy reach at all times.

NATURAL AND ARTIFICIAL INCUBATION.

Whether it will pay to buy incubators and brooders depends largely on one's circumstances. Where chicks are wanted in considerable numbers earlier than April 15th, an incubator becomes practically a necessity, as it is seldom that hens become broody in numbers until after the 1st of April. Again, where one wishes to hatch more than 150 chicks, an incubator is in many cases cheaper and better than the natural method. It is also a necessity where one is breeding from the non-setting varieties.

There are numerous illustrations of chicks being raised in large numbers by the natural method in the States of Rhode Island and Massachusetts, particularly in the former State. Where this method is followed, the chicks are hatched largely during the months of May and June; and where from 500 to 1,500 laying hens are kept, there is little difficulty in getting a sufficient number of broody hens. Those who are keeping large numbers of hens appear to be well satisfied with the natural method; but there can be no doubt that the number of incubators in use is increasing from year to year.

Hen and Incubator. As to results, I am of the opinion that *on the average*, the incubator will hatch as many chicks as the hen. There is no doubt that some individual hens hatch a much higher percentage than a machine; but when we put 240 eggs into a machine and the same number under 20 hens, our experience is that we get about equal results in the number of chicks hatched.

The average hatch is probably one chicken from every two eggs set. This, of course, varies with the different seasons, also with the percentage of fertile eggs, and the strength of the germ. We have found during the months of February and March, when the ground is covered with snow and the fowls are closely housed, that the percentage of fertile eggs is small, and that the germs are very weak. Under such conditions we have very poor hatches and chicks that are very hard to rear. Much better eggs are obtained in December and early January, or when the fowls get out into the fresh air and are able to pick some grass. Thus it will be seen that, as a general rule, as the percentage of fertile eggs increases, the vitality of the germ increases, the percentage hatched is larger and the mortality among the young chicks smaller. For example, we would expect to get a much larger percentage hatch of the fertile eggs from eggs that were 90 per cent. fertile than from those that were 60 per cent. fertile; and, moreover, we would figure on raising a much larger percentage of chicks from the former eggs than from the latter, owing to the chicks being stronger and having greater vitality.

Setting the Hen. It is generally agreed that, in order to secure a good hatch, the hen must be placed where other hens are not likely to disturb her; for, as a rule, we seldom get good hatches where

other hens lay in the nest with the sitter. Some farmers do not set a hen until one becomes broody on a nest where no others lay, which often necessitates late chicks. The difficulty can be overcome by making a new nest for the broody hen. Get a box about 12 inches square and 6 inches deep; put some earth, or an overturned sod, in the bottom, taking care to have the corners very full so that no eggs can roll out from the hen and get chilled; next put on about two inches of straw or chaff; and then put a few earthen eggs into the nest. Place the nest in some pen where nothing can disturb the hen, and put her on after dark. Feed and water must be within easy reach and a dust-bath should also be convenient. If the hen is sitting quiet the next day, you will be safe in putting the eggs under her. In our experience we get 90 per cent. of the hens to sit by following this method.

It should be remembered that the hen will be in better condition if dusted with insect powder when set, and also a few days before the hatch comes off. This will usually keep the lice in check, especially if some tansy or mint leaves are used in making the nest.

When hens are to be set in large numbers, I know of no better method than that adopted by the Rhode Island farmers. Early in the spring, the hens are set in any old outbuilding; later on they are set as seen in the cut, that is, the nests are stacked tier upon tier; a few boards serve as a shelter; and the wire run gives room for some green food, a dust bath, etc. The hens are generally let off to feed and water every other day. It is considered advisable to have an attendant present to see that the hens get back to the proper nests; also to prevent their fighting.

Incubators. There is really very little known about the running of incubators. Some people succeed in hatching a large percentage, while others, under exactly the same circumstances, fail. The exact reason why, we do not know. This much, however, can be said, the machine should not be placed in a direct draught, nor yet in a building where there is a lack of ventilation. Fresh air is one of the most important things in an incubator room. I have known machines to hatch well in well-ventilated cellars, kitchens, dining-rooms and bed-rooms. Hardly any two people agree as to which is the best place to operate the machine. As a general rule, it is wise to follow the manufacturer's directions. I find that different makes of incubators require different treatment, both as to temperature and otherwise, and we generally get the best results when running closely to the directions. Where possible, the temperature in the room should vary but little; for, if it varies 30 to 40 degrees in 24 hours, it is very hard to keep an even temperature in the machine; and it is absurd to expect that the machine will not vary with such changes in the surrounding temperature.

REARING OF CHICKS.

Chickens hatched in an incubator can be reared either with hens or with a brooder. Some people are able to make good hatches with their incubators; but they are unable to rear the chickens in brooders. In this case I would advise the use of broody hens for mothers; and the same would apply to those who have an incubator, but do not care to invest in a brooder.

The best plan I know of to get the broody hens to take the chicks, is to give the hen two or three eggs out of the incubator on the 18th or 19th day and allow her to hatch them. When your incubator hatch is over take a dozen or fifteen chickens and put them under the hen after dark. Even if they happen to differ in color from those she has hatched, she will mother them all the same. If you give them to her in the day time she may not do so. Never neglect to give the hen a thorough dusting before giving her any eggs. If there is one thing more than another that requires careful attention in rearing young chickens, it is to keep them free from lice. If lice get upon them, from the hen or elsewhere, a large proportion of them will be almost sure to die.

There are many good brooders upon the market which are well described in the manufacturers' catalogues; hence a description here is unnecessary. Personally, I am in favor of a three-compartment brooder, as it admits of keeping the chicks in near the heat when young, and on stormy days. The brooder lamp should always be arranged so as to give little chance of fire.

If the brooder can be placed in a small portable house, it is a good plan, as the brooder is thus protected from stormy cold winds in the early spring; also from the heat later on. The house protects the chicks from rain, and serves as a roosting coop after they become too large to stay in the brooder.

Chicks should not be fed until they are at least 36 hours old. It is a serious mistake to feed them earlier. Too early feeding is the cause of indigestion and bowel trouble in many cases. We try to keep the temperature of the brooder between 90 and 95 degrees throughout the first week. After the first week the temperature is gradually lowered, generally speaking, about 1 degree a day. When the chicks are put into the brooder, it is well to remember that every 15 chicks will raise the temperature of the brooder 1 degree. Be careful not to get your brooder too hot, nor yet so cool as to chill the chicks. This is very important, especially during the first 10 days.

The floor should be covered with dry sand or clover chaff before the chicks are put into the brooder. Luke warm water should also be put into the brooder for drink just before the chickens are taken from the machine. I have had best success in starting young chicks

on hard-boiled eggs, finely chopped, shell included, and bread crumbs—about 4 parts by weight of bread to one of eggs. This is fed dry. After the first two days we begin to give an occasional feed of seed chick-food, which is made as follows :

Cracked wheat.....	25 parts.
Granulated oat meal....	15 “
Millett seed.....	12 “
Small cracked corn.....	10 “
Small cracked peas.....	6 “
Broken rice.....	2 “
Rape seed ..	1 “
Grit (chicken size)	10 “

This can be used for the first feed and continued through the first 8 to 10 weeks with good results. We aim to feed the chicks five times a day. Generally after the first few days, there are three feeds a day of this chick-food, one of bread and milk (the bread being squeezed dry and crumbled), and one of whole wheat, or a mash made of equal parts of bran, shorts and corn meal, to which has been added 10 per cent. of animal meal or blood meal. If we can secure fresh liver and get it boiled, this is generally given twice a week, and the animal meal is than omitted from the mash. If the chicks cannot get out to run about, the seed chick-food may be scattered in the chaff, and the little chicks will work away most of the day for it. This gives them exercise, which is a necessity in rearing chicks. If there is no green food to reach, it must be supplied. Lettuce is excellent. Sprouted grains are very good, as is also root sprout, cabbage, rape, etc.

When the chicks get to be about 8 weeks of age, we usually feed about three times a day—the mash food in the morning and whole wheat and cracked corn at noon and night. If we are anxious to

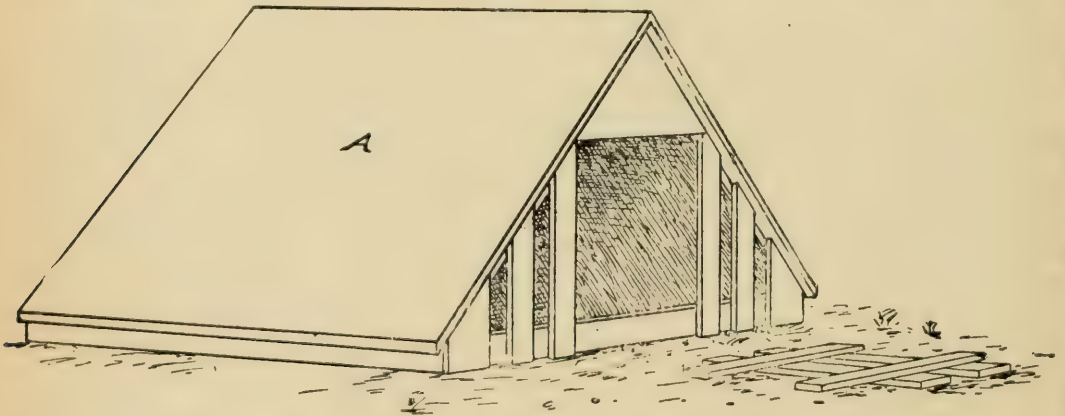


Fig. 11. Coop A.—Each side of roof, 24 in. by 30 in.; bottom, 2 ft. 4 in.

force the chicks, we give two feeds of mash and increase the animal meal a little.

The chicks are taken from the brooders at from 6 to 8 weeks of age, according to the weather. A small coop (Fig. 11.) is set in front of the brooder, so that the chickens cannot get to the brooder entrance, the result being that they get into the coop A. After a day or two take away your brooder, and the coop can then be moved daily to fresh ground. This will keep the coop clean. When the chicks get too large for the coop A, which will be in about ten weeks, they are put into coop B. (Fig. 12.) The same process is gone through

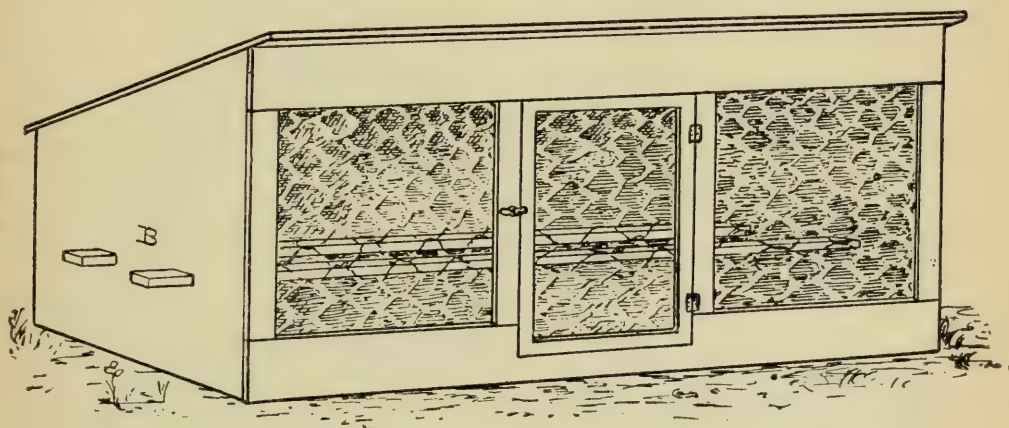


Fig. 12. Coop B.—Length, 6 ft. ; width, 2 ft. 6 in. ; height in front, 2 ft. 4 in. ; height at back, 18 in.

with coop B. It is set in front of coop A, so as to obstruct the entrance; and the chicks then go into the coop B, and soon take to the roost. Coop B will roost 20 chicks until full grown. Try to keep your chickens roosting in the open air as long as possible. Never house them in close, stuffy houses. If you do they will be sure to go wrong, become weak, and be of little or no value, either as breeders or egg-producers.

BREEDING MARKET FOWLS.

When looking over dressed poultry in some of the exporter's shops, I have often thought how easy it would be to improve the appearance of much of the ordinary poultry, and some of that which is specially fattened, if the birds were bred to a proper type. I have spent much time in examining different types of birds, alive and dressed, and in observing the feeding capacity of certain types; but it would take years to arrive at definite conclusions on these points. I am however of the opinion that one of the most important things to be sought after is *constitution*. This may have no actual market value, but it certainly has much to do with the bird's ability to grow and put on flesh. What we want is a good feeder, and an economical producer. Generally, a bird with a short, stout, well-curved beak, a broad head (not too long), and a bright, clear eye, has a good consti-

tution. And I have noticed that when a bird has a long, narrow beak, a thin, long comb and head, and an eye somewhat sunken in the head, it is usually lacking in constitution. Such a bird is likely to have a narrow, long body and long legs, upon which it seldom stands straight. There are some exceptions to this rule ; yet, generally speaking, if a bird has a good head, the chances are favorable for a good body ; and, if it has a poor head the chances are against it. I have frequently noticed in the Rose-comb breeds, such as Wyandottes, that a good-shaped one is seldom found with a long, narrow comb.



Fig. 13.

The neck should be moderately short and stout, indicating vigor. The breast is the most important point in a market chicken. It should be broad, *moderately* deep ; and, if broad, it will present a fine appearance and appear well-fleshed. It is quite possible that a broad

deep breast will carry more meat than a moderately deep breast of the same width ; yet there is no doubt but that the latter will present much the better appearance, and sell more quickly and at a higher price in the market.



Fig. 14.

When considering the length of breast, we must try to have it come well forward (see Fig. 13), and not be cut off at an angle, as in Fig 14. The body, in general, should present the appearance of an oblong when the head, neck, and tail are removed.



Fig. 15.

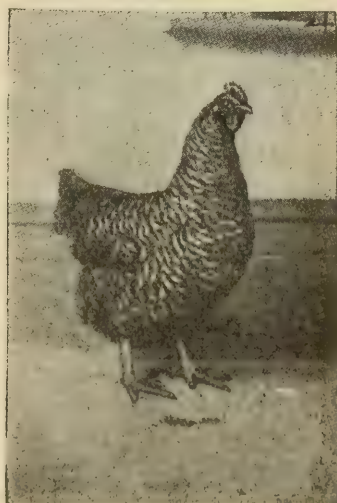


Fig. 16.



Fig. 17.



Fig. 18.



Fig. 20.



Fig. 19.

We frequently see birds that are very flat in front, and cut up behind, as in Fig. 15. Chickens of this class have a very short breast; and, if the breast happens to be deep, as it is in this bird, the chicken will have a very poor appearance when dressed, as it will show a marked lack of width and length of breast, with excessive depth. (Notice that the head is narrow and long, the body is narrow, the eye is bright but slightly sunken, the legs are long and not straight under the body).

In Fig. 14 observe the very flat breast, the length of back, the long neck and head, the narrow comb, the sunken eye, and the length of legs. The breast comes fairly well back, but not well forward.

In Fig. 13, the bill is short and stout, but not so well curved as it should be. Note the breadth of head, the prominence and brightness of the eye, the short, stout neck, the great width of the breast, the fulness caused largely by the breast bone extending well forward, the short, stout legs (straight under the body), and the width between the legs. There is an expression about this chicken that indicates health and the essence of vigor.

The back should be broad, to give lung and heart capacity; and the width should extend well back to the tail-head. We do not want the wedge-shaped back, as seen in some fowls that have great width at the shoulders and taper rapidly towards the tail-head.

It is much easier to get good-shaped market pullets than good cockerels. The market demands a five-pound bird when dressed, and farmers have gone into raising big chickens. To that end they are asking for large, overgrown cockerels, of excessive depth, for breeders; and the result is that we get dressed chickens weighing four to five pounds each, that have immense, high breast-bones and very long legs. These are not attractive to the buyers, and they sell at less price per pound than plumper birds. For example, if given two birds of the same width of breast, one is one and one-half inches deeper in the breast than the other. The result will be that one bird will look plump and sell readily, while the other will lack in plumpness and be slow in selling. This lack of plumpness can be bred out by using such males as that shown in Fig. 13.

We like to have birds as well built as we can get them; and Fig. 13 is as near the ideal market chicken as we have in the breed which he represents.

The hen, as seen in Fig. 16, is of a good market type. (Note the width and fulness of breast). As a breeder, she is a little fine in bone, and rather too small. She has, however, that blocky appearance which is desirable.

Fig. 17 is a photo of a cross-bred chick (sire, Buff Orpington; dam, Houdan). Note the length and fulness of the breast; also good beak and eye.

Fig. 18 is a ten week's old son of Fig. 13. You will observe the same general characteristics as seen in the father—fair beak, good eye, excellent breast, both as to length and width, without excessive depth. The thigh is also medium in length.

Fig. 19 shows a good head throughout, very full and wide breast, and legs that stand well under the body and well apart. This bird is of the type we like to feed in the fattening crate.

Fig. 20 represents the long, narrow sort. (Note the long beak, the narrow head, the sunken eye, the long neck, and long crooked legs). When dressed, his appearance will not be pleasing.

TRAP-NEST.

Fig. 21 represents a trap-nest made by the college carpenter. This nest is very simple in construction. The door is adjusted low enough so that the hen on entering raises it slightly, thus relieving the hook, which drops back and allows the door to fall. This nest works well. The only objection to it is that the fowls using it require to be pretty much of the same size. A small hen may not raise the door enough to unfasten it.

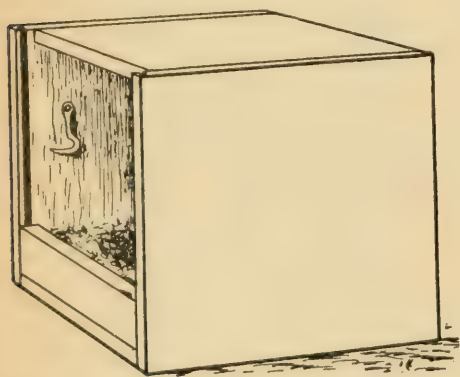


Fig. 21 (a). Showing hook which holds up the door. The nest is 12 inches wide, 12 inches high and 15 inches long.

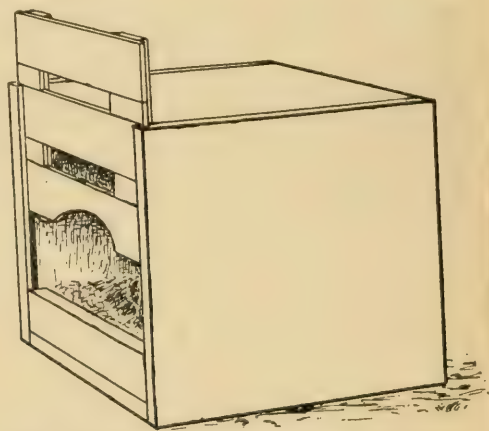


Fig. 21 (b). Nest set ready for the hen to enter.

Where one is anxious to build up a special strain of birds, either for special utility or for fancy exhibition purposes, the trap-nest, if looked after, will show what hens lay, and which hen lays certain eggs, thus enabling the breeder to know exactly what he is doing.

They require considerable time in the way of keeping records, and releasing hens after laying.

FATTENING CHICKENS.

A number of experiments have been conducted in fattening chickens for the market. There is an unlimited market for well-fleshed fowls in England, and the demand at home is constantly increasing. Fatted chickens were on September 18th, 1903, selling for 13 cents per pound in Montreal, and the dealers could not get nearly as many as they wanted.

The English market requires a white-fleshed chicken, and our best home market also appears to favor this color of flesh. Black-feathered chickens, and those having black legs are not in favor.

There is little use in trying to fatten scrub stock. Good pure-bred males of such breeds as Plymouth Rocks, Wyandottes, and Orpingtons can be purchased at moderate prices, and these only should be used to breed from. Very large chickens are not in favor. What is required is a meaty bird weighing from four to five pounds. The breast should be especially well developed, and should be plump, as this is the most valuable part of the body.

CONSTRUCTION OF FATTENING CRATES.

Fattening crates are usually made 6 ft. 6 in. long, 18 to 20 in. high, and 16 in. wide. The crate is divided into three compartments, each holding from four to five birds, according to the size of the

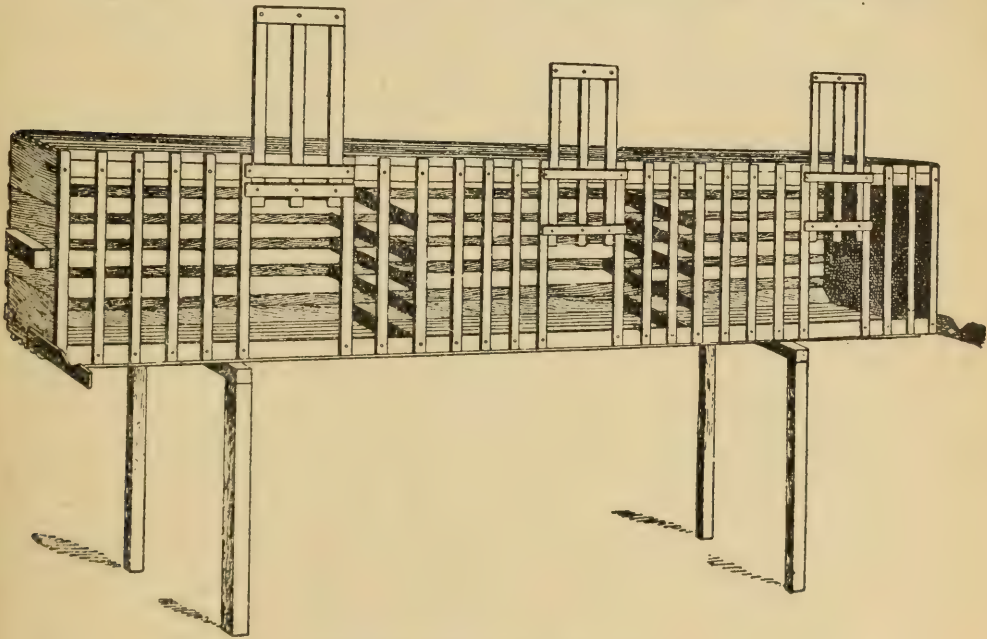


Fig. 22. Showing a single crate or coop.

chicken. The crate is made of slats, except the ends and partitions between the compartments, which are solid wood—those on the top bottom and back running lengthwise of the coop, while those on the front run up and down. The slats are usually $1\frac{1}{2}$ inches wide and

$\frac{5}{8}$ inches thick. Those in front are placed 2 in. apart to allow the chickens to put their heads through for feeding. The slats on the bottom are placed about $\frac{3}{4}$ inch apart, so as to admit of the droppings passing through to the ground. Care should be taken not to have the first bottom slat at the back fit closely against the back. An opening between the first slat and the back prevents the droppings from collecting and decomposing. The slats on the top and back are usually 2 inches apart.

There is a small V-shaped trough arranged in front of the coop for feeding and watering the chickens. This trough is from 2 to 3 inches deep and is generally made of $\frac{3}{4}$ inch lumber.

Very fair coops may be made from old packing boxes, by taking off the front and bottom, and substituting slats in their places, (see Fig. 22). During warm weather, these crates may be placed out of doors. They need to be protected from the rain which is easily accomplished by placing a few boards over them. In cold weather the crates should be placed in a house or shed where they are protected from raw, cold winds. When fattening chickens inside of a building, it is well to darken the building and keep the birds as quiet as possible.

After each lot of birds is killed, we paint the crates with some liquid lice-killer. Coal-oil and carbolic acid is very good. Use one gallon of coal-oil to one pint of crude acid. We have used some of the prepared mixtures with good results. If the birds (bought from different parties) are very lousy when put up, they should be well dusted with sulphur. The birds should be watered at least twice every day in warm weather. Grit should be given them twice a week.

During the first week, feed lightly,—never quite all the birds will eat. I prefer feeding three times a day during the first week, and twice a day during the succeeding weeks. It seldom pays to feed the birds longer than three or four weeks. Chickens weighing from three to three and one-half pounds each, that are thrifty and of good breeding appear to be the most profitable for feeding. Large chickens, weighing from five to six pounds, gain less and eat more than smaller ones.

Should a bird become sick in the crate, I find that if it is given a teaspoonful of salts and turned out on a grass run it will usually recover.

CRAMMING MACHINE.

The crammer consists of a food reservoir, to the bottom of which is attached a small force-pump moved by a lever and treadle which is worked by the foot of the operator.

Communicating with the pump is a nozzle, through which the food passes to the bird.

"A" is the food reservoir; "B," the pump; "E," the pump rod; "O," the lever, which on being depressed at the lettered end, causes the pump rod "E," to which it is attached, to move downwards, and to eject the contents of the pump "B" out of the nozzle "K." On relieving the pressure at "O," the lever and the parts connected therewith are drawn up by the spring "C," until the motion is arrested by a stop "M," which serves to determine the quantity of food ejected at each depression of the tread'e.

The charge may also be varied by arresting the pressure at any point in the downward thrust of the lever "O."

The illustration (Fig. 23) shows one method of operating with this crammer, and this plan is now largely followed in some parts of Sussex, England.



Fig. 23. Cramming machine for the forced feeding of chickens, turkeys, etc.

KIND OF FOOD USED IN CRAMMING MACHINE.

Not all kinds of foods can be used in the machine. The food must be in a semi-liquid condition in order to pass through the machine. This necessitates the use of some kind of grain that will stay in suspension in the milk, beef broth, or whatever liquid is used in mixing the grain. Finely ground oats, with the hulls removed, or

shorts, answer the purpose well. We use almost entirely the former food. Grain like corn-chop, or barley meal, are not suitable, as they sink to the bottom of the hopper and clog the machine. When cooked they work well, but are not good foods as is shown by experiments conducted here—see page 33.

The food is mixed to the consistency of ordinary gruel, or until it drips from the end of a stick.

WILL IT PAY TO BUY A CRAMMING MACHINE ?

For the ordinary person, I think not. First-class chickens may be had by feeding in the crate from the trough only ; indeed, I have had equally fleshy birds that have been fed for four weeks from the trough as where we have fed them two weeks from the trough and one week from the machine.

Where one has a special trade for high-class poultry, I am of the opinion that a more uniform product can be secured by using the machine. Machine-fed birds should realize at least one cent more per pound than trough-fed birds in order to pay for the extra labor, etc.

Birds that are fairly well fleshed when put into the crate will do better if put at once on the machine, instead of being crate-fed first.

FATTENING CHICKENS IN JULY.

Early in July, several groups of chickens were put in crates for fattening. The results are given below :

Lot I. consisted of 12 Barred Rock cockerels weighing, when put up in crate, a total of 37 pounds.

	Lbs. Grain Consumed.	Lbs. Skim-milk Consumed.	Lbs. Gain.	Lbs. of grain to make 1 lb. Gain.	Average gain per bird in 4 weeks.
First week.....	17	25	9	1.8	2.1 lbs.
Second week.....	24½	31	5	4.8	
Third week.....	20	30	8	2.5	
Fourth week.....	22	33	4	5.5	

Average of grain per lb. of gain in 4 weeks.....3.2 lbs.

They were sold to a Montreal firm at 15 cents per pound f.o.b. here.

These chickens were rather leggy, and had high breast bones, and would have dressed much better when they had reached a weight of 6 or 7 pounds.

Lot II. consisted of 8 high-grade Leghorns, weighing a total of $18\frac{1}{4}$ pounds.

	Lbs. Grain Consumed.	Lbs. Skim-milk Consumed.	Lbs. Gain.	Lbs. of grain to make 1 lb. Gain.	Average gain per bird in 4 weeks.
First week	7	10	4	1.8	1.28 lbs.
Second week	11	16	$1\frac{1}{2}$	7.3	
Third week	10	15	3	3.33	
Fourth week	7	10	$1\frac{3}{4}$	4.	

Average of grain per lb. gain in 4 weeks....3.4 lbs.

When dressed these chickens were somewhat plumper than the Rocks owing to their being mature, but they were rather small. They were sold at 13 cents per pound.

Lot III. consisted of 20 Pit Game Crosses, weighing 40 pounds.

	Lbs. Grain Consumed.	Lbs. Skim-milk Consumed.	Lbs. Gain per week.	Lbs. Grain to make 1 lb. gain.	Average gain per bird in 4 weeks.
First week	24	36	$9\frac{1}{2}$	2.6	1.77 lbs.
Second week	27	41	9	3.	
Third week	29	44	14	2.	
Fourth week	30	45	3	10.	

Average amount of grain per lb. of gain in 4 weeks....3.1 lbs.

These chickens dressed fairly well, the breasts being rather plump; but they had an excessive length of legs and neck. They were sold at 15 cents per pound.

All the lots were fed three times a day on the following rations:

Barley Meal	2 parts,
Corn Meal, or Chop	2 "
Shorts or Middlings	2 "
Finely Ground Oats	1 "
Animal Meal	1 "

This mixture was used with about one and one-half times its weight of skim-milk.

FEEDING ALL-COOKED FOOD.

We found it impossible to buy finely ground oats during the latter part of August, so we tried cooking rolled oats, barley, and corn-meal. The grains were used in the proportion of 50 per cent. of rolled oats and 25 per cent. each of barley and corn. These foods could not be used in the cramming machine without first being cooked.

Two groups of 12 birds were fed from the trough, one group for two weeks and the other only one week, with the following results:

Group I. consisted of 12 grade Plymouth Rock cockerels. They weighed when placed in the crates a total of $35\frac{3}{4}$ pounds. During the two weeks they consumed 103 pounds of cooked food, or equal to about 34 pounds of uncooked grain. They made a gain of five pounds. At the end of the two weeks the birds were very thin and sickly, their digestion being very bad. One of them died. The others were turned out on a grass run, and two of them died the second day they were out. The remainder are beginning to pick up again.

Another lot of 12 Rock chickens, weighing a total of 62 pounds, which had been fed the previous week on raw food, were given cooked food. During the week they were fed on cooked food they lost in weight, and three of them became so sick that they died. The remaining nine were placed on uncooked food the next week, and put on more than three-quarters of a pound each.

Two hundred chickens were crammed with cooked food. A few of the birds gained slightly, but the majority of them lost in weight. After having been fed in this manner for one week, a few of the best were shipped to a Toronto dealer, who complained about there being no meat on the breast. They sold for 9 cents per pound, live weight, while chickens fed on raw food sold for 13 cents per pound. The remaining birds were turned loose on a grass run.

The chief difficulty with the cooked food appears to be that it damages the chicken's digestion. Many of the birds that were put out on the grass run after being fed on cooked food have not recovered yet—three weeks after being turned out.

Cooked food can no doubt be fed to advantage in conjunction with raw food, but an all-cooked ration that is of a forcing nature appears to be entirely unsuitable for fattening fowls.

GRAIN RATIONS.

The following table shows the amount of feed consumed by the different groups of chickens, the cost of producing a pound of gain, and the number of pounds of grain it took to make one pound of gain.

Grain Rations.	No. of trials.	Weight when put in crates.	After two weeks' feeding.	Gain.	Grain consumed.	No. of pounds of grain to make 1 lb. gain.	Milk consumed.	Cost of pound of gain.	
		lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	
GROUP I—									
Cornmeal, 5 parts.....	Cost per cwt., \$1.10	First trial	43	55	12	35	2.916	35	3.5
Shorts, 4 parts.....		Second "	48.5	59.5	11	39	3.54	39	4.263
Pearl oat dust, 1 part.		Third "	49.5	61	11.5	38	3.3	38	3.974
Animal meal, 1 part..		Average	47	58.5	11.5	37.38	3.252	37.33	3.912
GROUP II—									
Cornmeal. 2 parts	Cost per cwt., \$1.23	*First trial	.....	.....	.....	.....	.....	.....	.....
Ground buckw't, 2 prts		Second "	48.5	65	15.5	42	2.54	42	3.363
Pearl oat dust, 1 part.		Third "	48	63	15	40.5	2.7	41	3.56
		Average	48.25	64	15.75	41.25	2.62	41.5	3.461
GROUP III—									
Cornmeal, 4 parts ...	Cost per cwt., \$1.22½	First trial	45	53	8	35	4.375	35	5.797
Ground buckw't, 2 prts		Second "	47.5	63	15	41	2.66	41	3.63
Pearl oat dust, 2 parts.		Third "	50	62	12	40	3.3	40	4.416
		Average	47.5	59.3 ₃	11.66	38.66	3.445	38.66	4.614
GROUP IV—									
Cornmeal, 2 parts.....	Cost per cwt., \$1.23	First trial	48	53.5	5.5	34.5	6.27	35	8.34
Pearl oat dust, 1 part.		Second "	48	60	12	38	3.18	38	4.22
		Third "	48	58.5	10.5	37	3.52	37	4.686
		Average	48	57.33	9.33	36.5	4.32	36.66	5.748
GROUP V—									
Pearl oat dust—cost per cwt, \$1.50		First trial	48	60	12	34	2.83	34	4.83
		Second "	49	63	14	40	2.85	40	4.57
		Third "	47.5	60	12.5	40	3.2	40	5.12
		Average	48.166	61	12.83	38	2.96	38	4.84

* This food was not used in the first trial.

The following prices were paid for grain: Corn meal, \$1.10 per cwt.; ground buckwheat, \$1.20 per cwt.; middlings or shorts, 90c per cwt.; animal meal, \$1.60 per cwt. There were 12 birds in each trial of each group. The last ten days of the feeding the birds were fed from the cramming machine, one and one-half pounds of milk being used to one pound of grain.

CONCLUSION.

Ration No. 1 is a good economical producer, but is objectionable, because it has a tendency to produce yellow flesh, which is undesirable in our best market.

Ration No. 2 is, perhaps, the most palatable of any, and it is one that makes a nice white flesh at a moderate cost.

Ration No. 3 is much the same as No. 2, except that it contains more corn-meal, which tends to make it less adapted for use during warm weather. Note the results of the first trial. It has a slight tendency towards producing a creamy flesh.

Ration No. 4 is the most unsatisfactory of all. The excess of corn in it decreases its palatability, and also makes it unsuitable for feeding during warm weather.

Ration No. 5 is a good one, when the oats can be purchased at moderate prices. I am of the opinion that rations Nos. 2 and 5 are both excellent, and which it would be advisable to use would depend largely upon the prices of the different grains.

GENERAL CONCLUSIONS.

1. It is evident from these experiments that chickens that are being fattened, produce a pound of gain at a less cost when fed in crates than when allowed to run at large in a pen.

2. That the birds fed in the crates from the trough and the cramming machine in addition produced a pound of gain at the least cost, the food consumed being taken into account only.

3. That feeding chickens in a pen loose, is not to be commended when the object is to fatten or flesh them for market purpose.

4. There is a slight difference in favor of a chicken weighing less than four pounds.

DRESSING AND SHIPPING POULTRY.

All fowls should be fasted from twenty-four to thirty-six hours before killing. Where this is not done, the food decomposes in the crop and intestines, the result being that the flesh becomes tainted and does not keep well.

There are two methods of killing that are considered proper. One is to kill by bleeding, which is accomplished by making a deep incision with a sharp knife in the roof of the mouth, immediately below the eyes. This method is considered to be the better one in

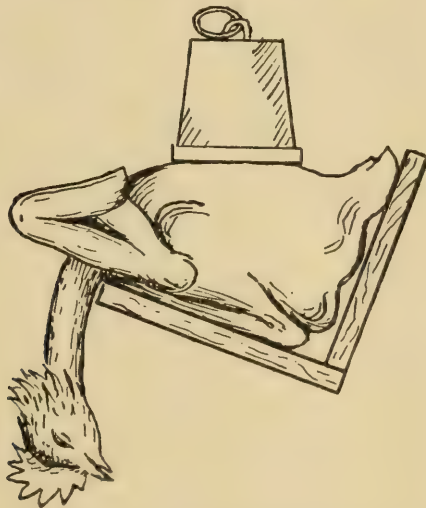


Fig. 24. A chicken weighted in shaping board. (Lewis Wright.)

the Eastern States and also in some parts of Canada. The other method is to kill the bird by wringing or pulling the neck. This is done by taking the chicken in the hands, stretching the neck, holding the crown of the head in the palm of the hand, and giving a quick turn backward, and at the same time a steady pull. This method is favored by the exporters of dressed fowls, and is much cleaner than

bleeding the fowls. It is claimed by the exporters that the flesh will keep longer and will not be so dry as where the birds are bled. I prefer the latter method.

After the bird is killed, plucking should begin at once. Care should be taken to keep the head downward, to allow the blood to collect in the neck. Where the birds are allowed to become cool before being plucked, it is very hard to avoid tearing the skin; and the plucking is much more tedious. The birds should be plucked clean with the exception of about two inches of feathers adjoining the head.

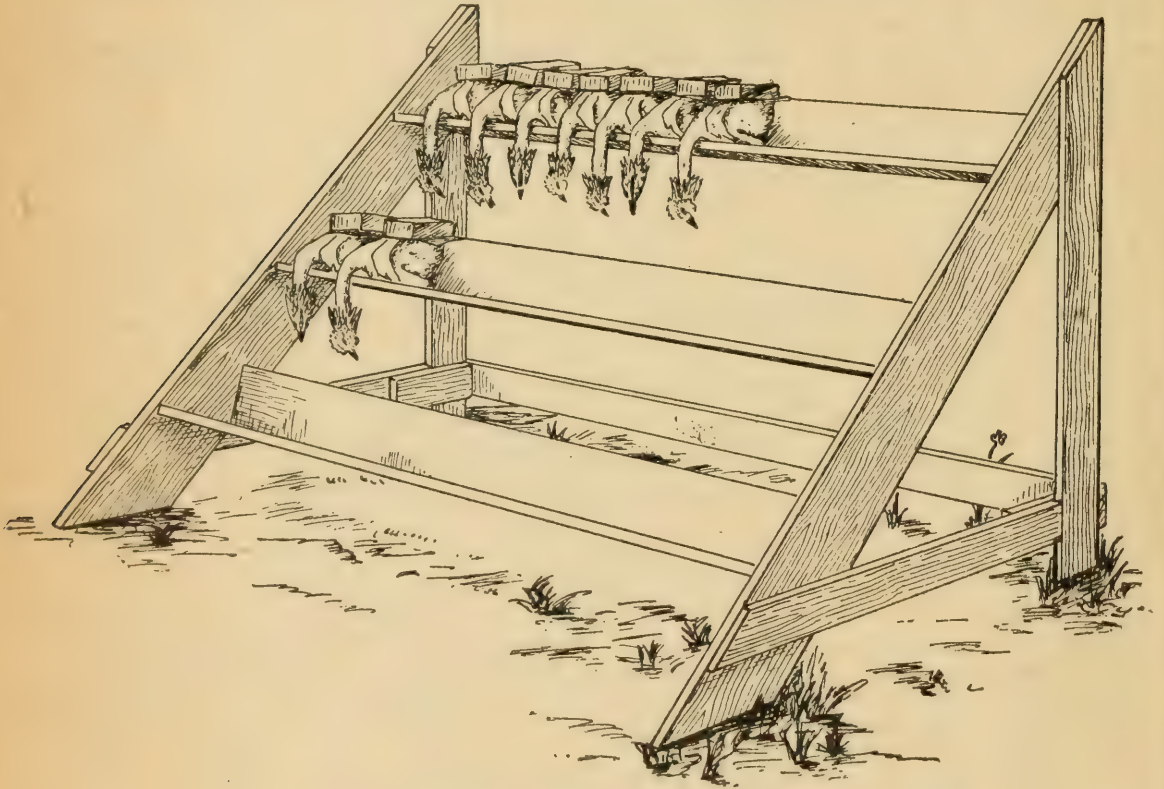


Fig. 25. Showing a number of chickens in the shaping boards.

After the chicken has been plucked, it should be placed on a shaping board, as seen in Figs. 24 and 25. The weight placed on the top of the chicken is used to give it a compact appearance. This weight may be of iron, as seen in the cut, or a brick may be used in its place. If chickens are hung by the legs after being plucked, it spoils their appearance, making them look thin and leggy.

Many good chickens are spoiled by being packed before they are thoroughly cooled. Care should be taken that all the animal heat is out of the body before the fowls are packed. We always cool the birds at least twelve hours before packing them.

The chickens are packed in boxes as seen in Fig. 26. The box is lined with parchment paper; and, if the chickens are to be shipped a long distance, each bird is wrapped in paper. This prevents the

chickens from bruising each other, and at the same time, to a considerable extent, checks decomposition. Do not use ordinary wrapping paper, as it draws dampness, and will cause the chickens to become clammy, which makes them more or less unsaleable.

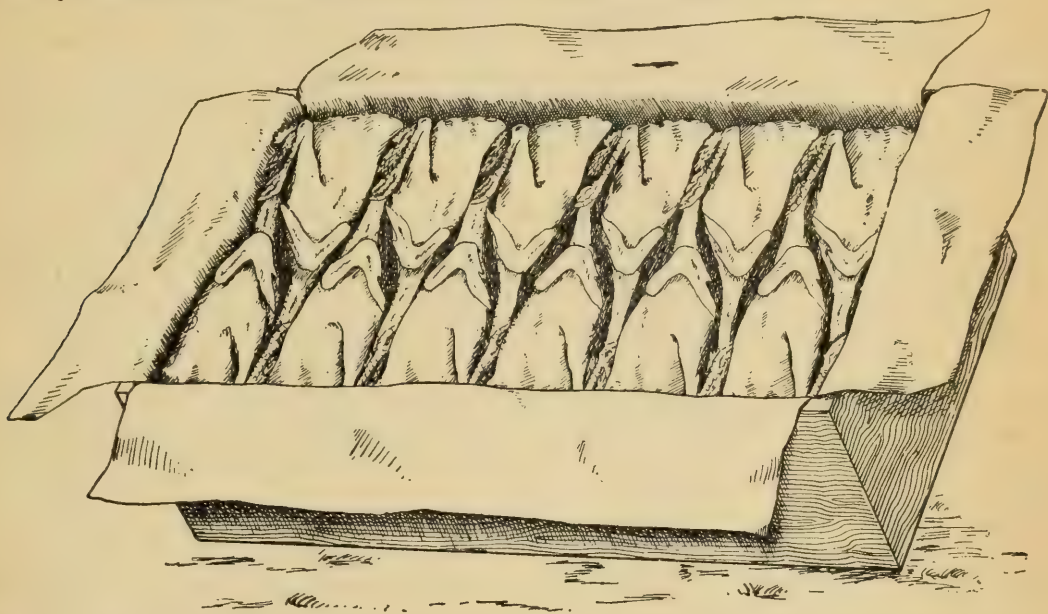


Fig. 26. Showing the top layer of chickens in a shipping case as used for local trade. This is one system of packing dressed poultry. The boxes are usually made 3 feet long, 17 inches wide and 7 inches deep for 24 chickens weighing about 5 pounds each.

There are several other kinds of boxes used for shipping poultry. Nearly every exporter has his own shape of box, and his own method of packing. For shipping locally, we use a box three feet long, twelve inches wide, and twelve inches deep. The chickens are packed similar to those seen in Fig. 26, with the exception that they are three tiers deep. The box will hold thirty-six $4\frac{1}{2}$ -pound chickens. The boxes are made strong so that we can have the dealer return them to be refilled. Do not use cedar in the construction of the boxes, as in some cases it taints the flesh. Basswood or spruce answers well.

EGG PRESERVATION.

Several methods of preserving eggs were tested in our Poultry department during the year of 1900. The eggs for this purpose were taken early in June, and were tested in December. Many of the same methods that proved fairly successful in previous years were again tried.

Method No. 1. A solution composed of one part water glass (sodium silicate) and five parts water that had been previously boiled. This was a very strong solution, and unless an egg was absolutely fresh it would not sink in the solution.

The eggs from this solution were of fairly good flavor, and all were well preserved.

Method No. 2. This was similar to No. 1, except that eight parts of water were used instead of five parts. The eggs in this were nearly as good eggs as those in No. 1. This is a good preservative where it is desired to keep summer eggs for winter use.

Method No. 3. This was composed of ten parts of water to one part of water glass. There were no bad eggs in this solution, but the eggs were inferior in flavor and in poaching quality to those kept by methods No. 1 and No. 2.

Method No. 4. This consisted of the same solution as No. 2; but in place of allowing the eggs to remain in the liquid, they were removed after having been in it for a week, except the last lot, which was put into the solution. This lot was left in the solution for the remainder of the season.

(a) The eggs, after being in the solution for a week, were removed and placed in an ordinary egg case in the cellar. They were all good when tested, but had evaporated considerably and were lacking in flavor.

(b) These were the second lot of eggs to be placed in the liquid. They were handled similarly to those in (a), and were of about equal quality.

(c) These eggs were allowed to remain in liquid. They were well preserved, all being good.

They were scarcely equal in quality to those from No. 2 method, but were superior to those from No. 3.

Method No. 5. A lime solution made as follows:

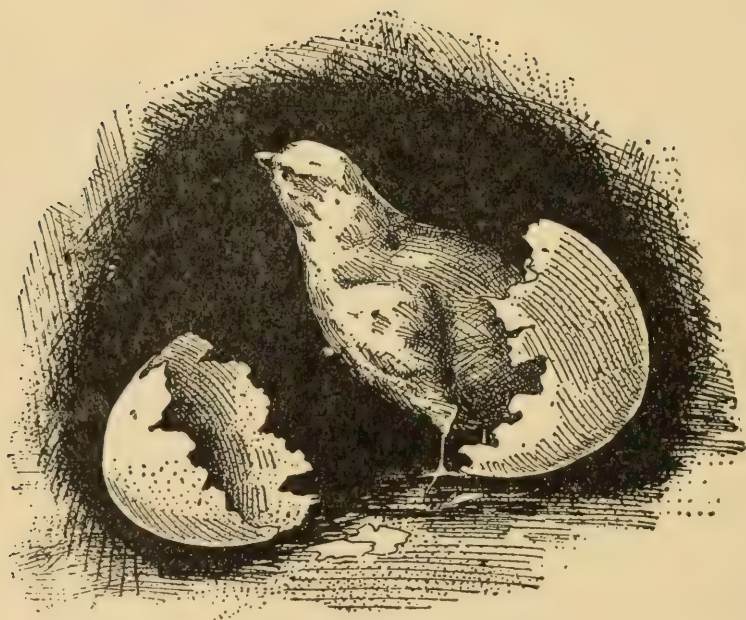
Two pounds of fresh lime were slacked in a pail and a pint of salt was added thereto. After mixing, the contents of the pail were put into a tub containing four gallons of water. This was well stirred and left to settle. Then it was stirred thoroughly the second time and left to settle; after which the clear liquid was poured over the eggs, which had previously been placed in a crock or tub. Only the clear liquid was used.

These eggs were well preserved; but those from the bottom of the tub had a decidedly limey taste, and the yolk in them was somewhat hardened.

ONTARIO AGRICULTURAL COLLEGE BULLETINS.

PUBLISHED BY THE ONTARIO DEPARTMENT OF AGRICULTURE, TORONTO.

Serial No.	Date.	Title.	Author.
101	April 1896	Dairy Bulletin (out of print, see No. 114)	Dairy School O.A.C.
102	May 1896	Experiments in Cheesemaking	H. H. Dean
103	Aug. 1896	Experiments with Winter Wheat	C. A. Zavitz
104	Dec. 1896	Rations for Dairy Cows (out of print)	G. E. Day
105	April 1897	Instructions in Spraying (out of print, see No. 122)	J. H. Panton
106	June 1897	The San Jose Scale	J. H. Panton
107	May 1898	Dairy Bulletin (out of print, see No. 114)..	Dairy School
108	Aug. 1898	Experiments with Winter Wheat	C. A. Zavitz
109	Sept. 1898	Farmyard Manure..	G. E. Day
110	Jan. 1900	Experiments in Feeding Live Stock (out of print)	G. E. Day
111	Dec. 1900	Lucerne or Alfalfa	R. Harcourt
112	Dec. 1900	Foul Brood of Bees	F. C. Harrison
113	March 1901	Sugar Beet Experiments in Ontario	A. E. Shuttleworth
114	May 1901	Dairy Bulletin	Dairy School
115	July 1901	Comparative Values of Ontario Wheat for Bread- making Purposes	R. Harcourt.
		Notes on Varieties of Winter Wheat	C. A. Zavitz.
116	Aug. 1901	The Hessian Fly in Ontario	Wm. Lochhead
117	Jan. 1902	Pasteurization of Milk for Butter-making	{ H. H. Dean F. C. Harrison
118	Jan. 1902	Yeast and its Household Use	F. C. Harrison
119	April 1902	Ventilation of Farm Stables and Dwellings	J. B. Reynolds
120	May 1902	Bitter Milk and Cheese	F. C. Harrison
121	June 1902	Ripening of Cheese in Cold Storage Compared with Ripening in Ordinary Curing Rooms	{ H. H. Dean F. C. Harrison
122	June 1902	Spray Calendar	Wm. Lochhead
123	July 1902	Cold Storage of Fruit	{ J. B. Reynolds H. L. Hutt
124	Dec. 1902	Nature Study, or Stories in Agriculture	Staff, O. A. C.
125	Dec. 1902	Roup (A Disease of Poultry)	{ F. C. Harrison H. Streit
126	April 1903	Peas and the Pea Weevil	{ C. A. Zavitz Wm. Lochhead
127	May 1903	Farm Poultry	W. R. Graham



SOME COMMON ONTARIO WEEDS.

BY

F. C. HARRISON, Professor of Bacteriology, and WILLIAM LOCHHEAD, Professor of Biology.

A leading educational authority lately said he did not believe that one farmer in a dozen could give the generally accepted common names of twenty of our common weeds. Whether this be so or not, one thing is certain, viz., that noxious weeds are spreading very rapidly in the Province of Ontario, and farmers need all the information they can get in preventing further loss from this very serious hindrance to successful agriculture. Hence the preparation of this bulletin for the Committee on Economic Botany appointed by the Experimental Union in connection with the Ontario Agricultural College.

The writer wishes to express his thanks for the assistance rendered by Wm. McCallum, B.S.A., who has labored unremittingly in collecting plants and in arranging material; and to Norman Ross, B.S.A., for his exact and artistic pen-drawings of the plants found in the bulletin. Mr. Ross made the drawings from specimens collected in this vicinity and from photographs taken in the laboratory.

WHY WEEDS ARE INJURIOUS.

A weed has been defined as any plant out of place; and, in that sense, a wheat plant in a field of turnips is a weed.

Most weeds do considerable, and some very much, injury to the crops in which they are found. They produce these effects in several ways:

1. *They absorb soil moisture.* The amount of water which is taken up by weeds and evaporated from the surface of the leaves is very great. For instance, an average Mustard plant pumps from the soil about fourteen ounces, or seven-tenths of a pint, per day; a sunflower, thirty-three ounces; and so on. The transpiration is generally in proportion to the surface of the leaf; but thin leaves transpire, or throw off water, more freely than fleshy ones. Consequently weeds having large leaf-surface draw from the soil and give off through the leaves a large amount of water, and thereby rob the surrounding plants. Many botanists consider this waste of moisture the most serious injury done by weeds.

2. *They use plant food.* Weeds naturally make use of the same food as the cultivated plants among which they grow. Consequently they deprive a crop of a large amount of the available nourishment; and

they rob the succeeding crop as well. For example, an analysis of the Russian Thistle by Snyder showed "that it contains from 12 to 17 per cent. as much nitrogen as there is in clover; and an ordinary thistle of this kind covering a square yard takes more potash and lime from the soil than two good crops of wheat from the same area."

3. *They shade, crowd, and choke useful plants.* Weeds often grow more vigorously than useful plants; and, as a consequence, they shade, or crowd, or partially choke the seedlings of the desired crop. Black Bindweed (Fig. 20), for instance, often covers completely a large part of the plants among which it grows.

4. *They increase the labour and expense of cleaning seed.* At best, it is difficult to clean many of the smaller seeds, such as clover, grass, and rape seed; and the difficulty is greatly increased when they are grown on a dirty farm. It is almost impossible to clean clover seed by winnowing. Hence the necessity that the land on which it grows be clean.

5. *They interfere with a regular rotation of crops.* A well balanced rotation of crops conserves the fertility of the soil; but it is often necessary to depart from such a rotation when noxious weeds get possession of the farm—to give undue attention to the growth of hoed crops, for instance, or almost omit a certain crop altogether for a time, as in the case of the oat crop on a farm overrun with wild oats.

6. *They harbor the spores of injurious fungi.* Many of the rusts which attack grain crops find a resting place on weeds of the grass and other families, which preserve them through the fall, winter, and spring.

7. *Lastly, they offend the eye, or are, as we say, an eyesore to good farmers and all people of taste.* They also interfere with the use of mowers, binders, and other implements in taking off crops.

INTRODUCTION AND SPREAD OF WEEDS.

Most of the injurious weeds found in this Province have come directly or indirectly from other countries. They are brought in and conveyed from field to field and farm to farm in various ways:

1. *By the wind.* Seeds which are carried by the wind usually have tufts of fine silky hair attached to them. Such are the seeds of the Dandelion, Canada Thistle, Sow Thistle (annual and perennial), Willow Herb, and Cotton Grass. These and similar seeds are wafted to and fro, till they become attached to the soil and commence to grow. In some cases, as in the Dock and Wild Parsnip, the seeds are winged; in others the pod containing the seed has flat and extended edges, exposing much surface to the wind. The Penny Cress is an example of the latter.

Some weeds are rolled along the ground by the wind. To this class belong the Russian Thistle and the Tumbling weed of the North-

west. When these weeds ripen, they break off close to the ground ; and being light, they are easily carried by the wind, especially on an open prairie, and the seeds drop out as the weed rolls from place to place.

An examination of snow drifts in Dakota, a few years ago, showed the presence of many weed seeds. Thirty-two seeds of nine species were found in two square feet of a drift. In the same place it was observed that a twenty-five mile wind carried wheat seed a distance of thirty rods in a minute.

Seeds which become sticky when wet often adhere to leaves, and go wherever the leaves are carried by the wind. This is true of the Plantain.

2. *By water.* Some seeds, especially those of aquatic plants, are distributed by water. Darwin maintained that many seeds, dropping into the sea or being washed in from the shore, might be carried nearly thousand miles by the movements of the water without injuring their vitality. Seeds which float on the surface of water are carried to and fro by the wind till they find a lodgment and begin to grow ; and many, of various kinds, are carried from high to low ground and distributed far and near by the rills and streams which flow from mountain, hill, and upland after heavy rains and spring thaws. The common Speedwell and Ragweed are often distributed in this way.

3. *By birds and other animals.* Seeds are distributed by animals in a variety of ways. "It is estimated that about ten per cent. of all flowering plants possess seeds which are dispersed by means of barbed or cleaved processes." By these barbs or processes the seeds cling to the feathers of birds and the hairy coats of animals, and in this way are carried from place to place. To this class belong the Bur, Burdock, Hound's Tongue, Bedstraw, Cockle, and such like. And the seeds of some plants, such as Mistletoe and the Meadow Saffron, exude sticky substances which cause them to adhere to birds and other animals.

In the hardened earth taken from the feet of birds Darwin found a large number of seeds, many of which germinated ; and it is undoubtedly true that seeds are often conveyed from one place to another in the dirt that clings to the feet of animals.

Seeds often pass through the stomachs of animals without being digested ; and during their passage they are conveyed hither and thither by the animal and finally deposited, to grow and reproduce their kind, whether of weeds or useful plants. Every farmer knows the truth of this statement as regards cattle, horses and swine ; and it may be mentioned that Darwin picked from the excrement of small birds twelve kinds of seeds which were perfect in form and germinated in nearly every instance.

Ants, locusts, and other insects also, do something in the way of distributing the seeds of certain plants, including noxious weeds.

4. *By man.* Man himself, however, has most to do with the spread of troublesome weeds, chiefly through the agency of railroads, implements, farm yard manure, feed stuffs, and impure seed

Many weeds are carried from one province or country to another in the fodder and litter used by animals in transit on railways and in grain carried by rail. More or less of the grain, litter, and fodder are scattered at places along the track, and at stations where grain and animals are unloaded and cars cleaned out. Weeds thus get a start and spread to neighbouring farms. The Russian Thistle was introduced in this way.

The constant changing of implements, with dry earth, pieces of sod, etc., attached to them, from field to field, and from one farm to another, is a common method of spreading weed seeds all over farms and throughout whole neighborhoods; and threshing machines from dirty farms are well known sources of trouble under this head.

Fresh farmyard manure from city stables is very often full of weed seeds, and should be rotted or piled and allowed to heat thoroughly before it is applied to clean land. Wild lettuce, for example, was brought from Toronto to the neighborhood of Burlington in manure; and in this way many other pests have been distributed from towns and cities to the farms of the Province.

A FEW FACTS REGARDING WEED SEEDS IN CLOVER AND GRASS SEEDS.

Of many hundreds of samples of commercial clover and grass seeds which were analyzed at the Agricultural College during the last two or three years, very few were free from noxious weed seeds. Many samples were *foul*, and there is no doubt that the sowing of an immense number of weed seeds accounts largely for the alarming spread of noxious weeds in recent years. The analyses made by the Department of Agriculture at Ottawa confirm those made at the College.

To give an idea of the *foulness* of many of the samples analyzed the following statements of some of the results may be valuable: In 1894, each of 12 samples of clover out of 60 contained 200 weed seeds to the ounce; another and the worst sample contained 9,080 weed seeds per ounce of clover seed. In 1902, fifty samples of clover and timothy were examined, and the percentage *purity* of the red clover seed ranged from 72 to 97 per cent. One sample contained 10,538 weed seeds per pound! In 1903, over 150 samples were examined, and the results were just as startling.

The following weed seeds were found in *common red clover*: rib-grass, curled dock, green foxtail, lamb's quarters, Canada thistle, white cockle, broad-leaved plantain, false flax, shepherd's purse, worm-seed mustard, ragweed, mayweed, sheep sorrel, black medick, pepper grass, ox-eye daisy, and chicory.

In *white Dutch clover*: Broad-leaved plantain, pepper grass, rib-grass, may weed, sheep sorrel, yellow foxtail, and lamb's quarters.

In *crimson clover*: white cockle, pigeon weed, wild mustard, sheep sorrel, and poppy.

In *flax seed*: lamb's quarters, yellow foxtail, lady's thumb, white cockle, false flax, wild buckwheat, curled dock, wormseed mustard, burdock, wild mustard ragweed, hawkweed, and barnyard grass.

In *spring wheat* from the North-west: great ragweed, common ragweed, wild oats, corn cockle, wild buckwheat, and tumbling pigweed.

In *cultivated oats* exposed for sale: wormseed mustard, lamb's quarters, spiny sow thistle, night-flowering catchfly, lady's thumb, shepherd's purse, Canada thistle, sour dock, broad-leaved plantain, smartweed, pepper grass, wild tare, and black medick.

In *alsike clover*: rib-grass, curled dock, sheep sorrel, broad-leaved plantain, false flax, foxtail, Canada thistle, white cockle, lamb's quarters, wormseed mustard, shepherd's purse, ox-eye daisy, night-flowering catchfly, mayweed, mouse-ear chickweed, lady's thumb, and sour dock.

In *timothy seed*: false flax, sheep sorrel, wormseed mustard, pepper grass, foxtail, rib-grass, shepherd's purse, curled dock, lamb's quarters, white cockle, Canada thistle, broad-leaved plantain, Norway cinque-foil, catnip, ox-eye daisy, spiny sow-thistle, night-flowering catchfly, mouse-ear chickweed, mayweed, pigweed, stickseed, horseweed, wild mint, corn cockle, chess, old witch grass, yellow avens, Kentucky blue grass, and ergot.

In the foregoing list the weed seeds are given in the order of relative abundance.

COLLECTION AND IDENTIFICATION.

Not only every seedsman, but every farmer, and every teacher in a rural school, should have a collection of weed seeds for reference and comparison, in order that he may be able to detect and identify such seeds when they are in grass seed, clover seed, rape seed, or any other kind of seed which is sold or offered for sale. A good collection can be easily made in the summer months. All that is necessary is a number of small bottles and a little attention at the right time. The so-called homeopathic vials of one drachm capacity are suitable for the purpose, but they should be carefully and plainly labelled. If they are not so labelled, the collection will be valueless.

DESCRIPTIONS OF THE WEED-SEEDS ILLUSTRATED ON OPPOSITE PAGE.

1. *Green Fox-Tail*. About one-twelfth of an inch long ; oval with blunt ends ; unequally bi-convex ; brown and often mottled ; surface granular and striate.

2. *Chess*. About one-third of an inch long ; back rounded ; glume 7-nerved ; middle nerve projecting as an awn ; the plate bears a row of spine-like hairs along each nerve.

3. *Wild Oat*. About three-fourths of an inch long ; spindle-shaped ; glume 9-nerved, middle nerve forming a twisted and bent awn ; a tuft of brownish hairs arise from scar at base.

4. *Couch Grass*. Seeds about one-half inch in length ; rather slender ; oval ; and tipped with a short awn.

5. *Curl Dock*. One-eighth to one-twelfth of an inch long ; pointed elliptical, with three faces ; surface smooth ; reddish brown.

6. *Sheep Sorrel*. Seeds about one-twentieth of an inch in length ; usually greyish or reddish brown, and finely roughened ; provided with three equal faces, egg-shaped, each face of the cover of the seed bears central ridges with branches.

7. *Lamb's Quarters*. Circular, lens-shaped, and black ; grooved on one face ; often partially covered with the seed covering.

8. *Purslane*. One-twenty-fourth to one-twenty-fifth of an inch in diameter ; jet black ; flattened egg-shaped ; notches at smaller end ; surface finely roughened.

9. *Corn Cockle*. Seeds from one-twelfth to one-eighth of an inch long ; angular in outline ; color jet black, occasionally dark brown ; each surface is crowded with ridges or spines arranged in circular rows leading from the scar.



The small drawings beside the enlarged drawings represent the natural size of the seeds.

DESCRIPTIONS OF THE WEED-SEEDS ILLUSTRATED ON OPPOSITE
PAGE.

10. *Bladder Campion*. About one-sixteenth of an inch in length; kidney-shaped; surface roughened by many little projections arranged more or less in concentric rows; light brown in color.

11. *White Cockle*. Resembling Bladder Campion, but lighter in color; roundish and not so angular; depression about scar not so well marked.

12. *Night Flowering Catchfly*. Resembles white cockle.

13. *Pepper-Grass*. About one-sixteenth of an inch in length; egg-shaped but much flattened; the groove is curved and quite evident; the scar is white; reddish yellow to reddish brown.

14. *Penny Cress*. Seeds one-twelfth of an inch long; somewhat egg-shaped and flattened; surfaces have 12-14 curved ridges, which start and end at the pointed end of the seed; color dark reddish brown.

15. *Wild Mustard*. One-sixteenth of an inch in diameter; dark brown to reddish brown in color; almost spherical in outline.

16. *Worm Seed Mustard*. About one-twenty-fourth of an inch in length; most are pointed at the end opposite the scar; the groove is quite evident; surfaces smooth and dull; reddish yellow in color.

17. *Shepherd's Purse*. About one-twentieth of an inch in length; somewhat flattened; oval; each face has two grooves; color reddish yellow.

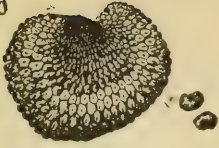
18. *False Flax*. Reddish brown; more or less oval and slightly flattened; about one-twentieth of an inch long; the groove more evident on one face than on the other; a whitish scar at one end.

19. *Field Bindweed*. About one-sixth of an inch long; oval; color dark brown; surface is somewhat roughened; outer face convex; inner face divided by a ridge into two plane faces.

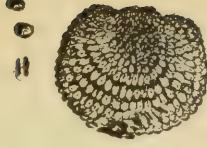
20. *Dodder*. Ranging from one-sixteenth to one-twenty-fourth of an inch in length; slightly egg-shaped and flattened; notched near one end; resembles clover seed; color is yellow to dark brown and reddish.

21. *Hound's Tongue*. Seeds are spiny nutlets, one-eighth of an inch long; upper side flat, oblique and roughened with hooked prickles.

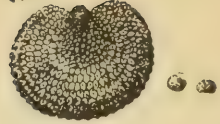
10



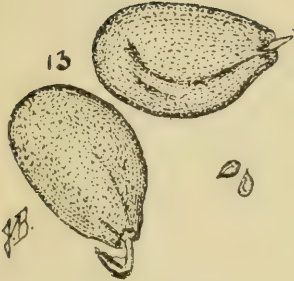
11



12



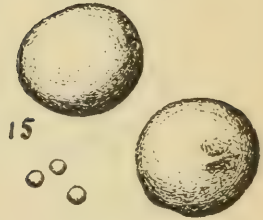
13



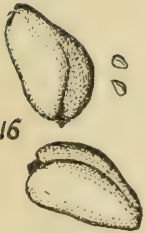
14



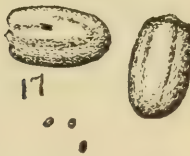
15



16



17



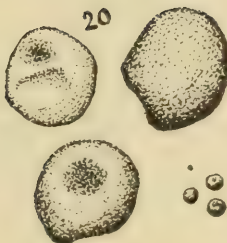
18



19



20



21



The small drawings beside the large drawings represent the natural size of the seeds.

DESCRIPTIONS OF THE WEED-SEEDS ILLUSTRATED ON OPPOSITE
PAGE.

22. *Blue Weed*. Stone-like in hardness; about one-tenth of an inch in length; surface roughened and of a gray color; the scar is large and triangular at flat end; the ridge along the outer face is convex.

23. *Mullein*. About one-twenty-fifth of an inch in length; thimble-shaped; base flat with scar at centre; thimble slightly six-sided, each side deeply pitted; pits of adjacent rows alternate; light to dark brown.

24. *Rib-Grass*. From one-eighth to one-twelfth of an inch in length; oval in shape with one face rounded, the other deeply grooved bearing a central scar; dark brown or amber colored.

25. *Ragweed*. Ranging from one-fifth to one-twelfth of an inch in length; top shaped; apex pointed, and bearing a crown of four to eight spines; light to brown in color.

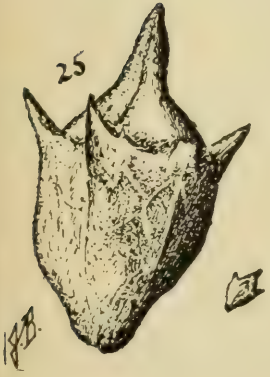
26. *Yarrow*. Seeds about one-twelfth of an inch long; small and thin; slightly egg-shaped; color varying from yellowish-white to gray.

27. *Ox-Eye Daisy*. About one-twelfth of an inch long; ten slender, white ribs running from end to end; a knob at the broad end; and slightly club-shaped.

28. *Burdock*. One-fifth to one-fourth of an inch in length; prismatic and mottled; four or five faces; apex broader than base; apex star in centre of a distinct brown ring.

29. *Canada Thistle*. From one-eighth to one-twelfth of an inch in length; brown in color; somewhat spindle-shaped, but often flattened; top end cup-shaped with a rim and a small central knob.

30. *Chicory*. From one-eighth to one-twelfth of an inch in length; usually light brown; usually cylindrical; top flat and crowned with scales.



The small drawings beside the enlarged drawings represent the natural size of the seeds.

DESCRIPTIONS OF THE WEED-SEEDS ILLUSTRATED ON THE OPPOSITE
PAGE.

31. *Prickly Lettuce*. Seeds one-eighth to one-sixth of an inch in length; broadly lance-shaped; each face has 5-7 ribs; color dark brown, somewhat mottled with black; apex is tipped with a beak which is almost as long as the seed.

32. *Spiny Sow Thistle*. One-eighth of an inch in length; varying from oval to lance-shaped; flat; each face bearing three narrow ridges which meet at the ends; surfaces smooth; color straw-colored to reddish brown.

33. *Perennial Sow Thistle*. Slightly spindle-shaped with blunt ends and often much flattened; five coarse, finely wrinkled ridges running lengthwise on each face; dark reddish-brown; about one-eighth of an inch long.

34. *Fleabane*. Seeds one-twentieth of an inch long; oval; remnants of pappus bristles remaining often at the apex.

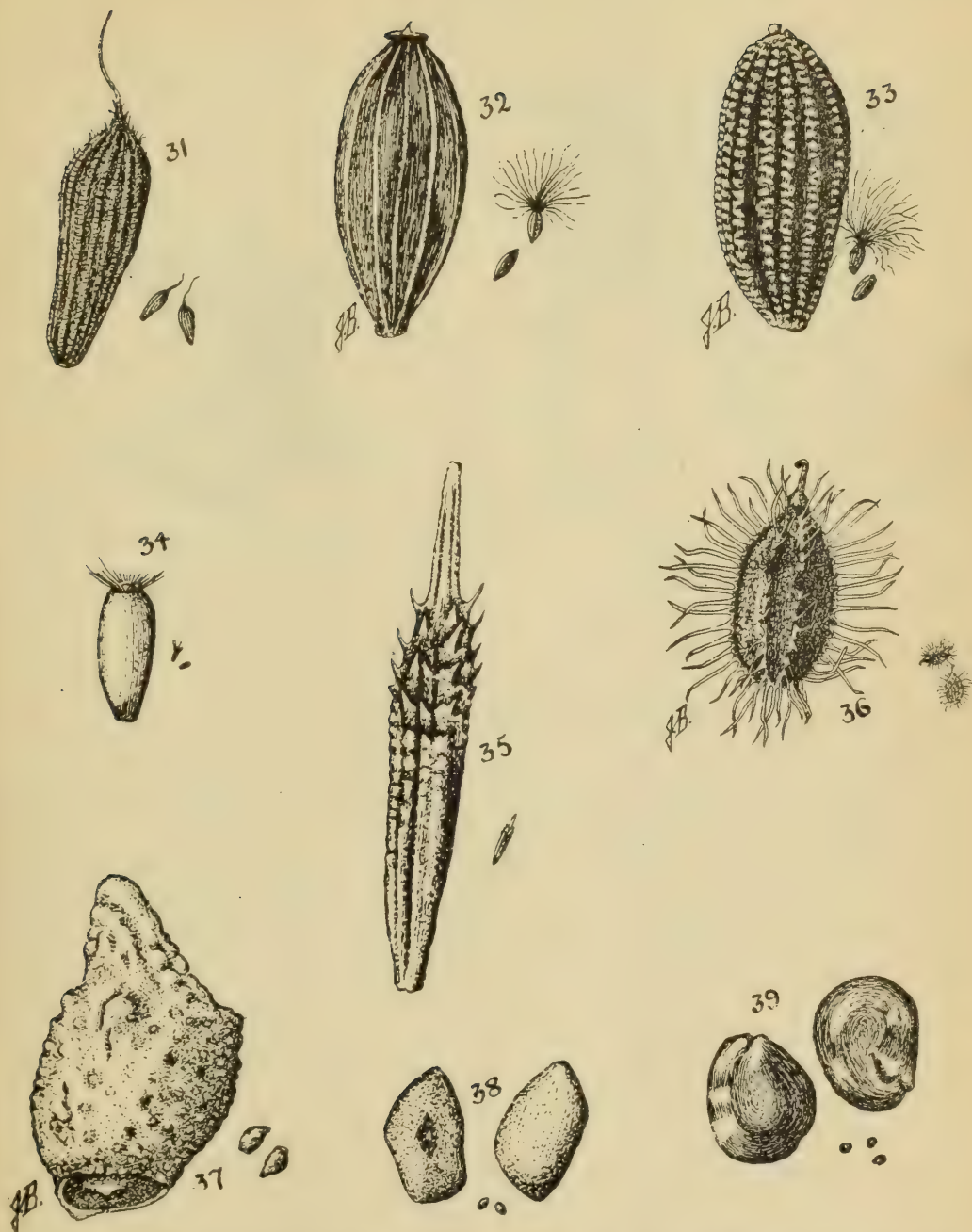
35. *Dandelion*. Seeds one-eighth of an inch long; exclusive of short beak; lance-shaped in outline; ten ridges running lengthwise; provided with barb-like teeth towards the apex; color varies from light to dark brown.

36. *Wild Carrot*. Seeds each one-eighth of inch in length; and flattened on the back; primary ribs slender, bristly, and five in number; secondary ribs, 4 in number, each bearing a row of barbed prickles.

37. *Pigeon Weed*. Nutlets one-twelfth of an inch long; egg-shaped and curved; scar is conspicuous; surface roughened; gray in color.

38. *Broad-Leafed Plantain*. Seeds about one-twentieth inch long; flattened; outline variable from oval to rhomboidal; wavy lines on surface; color, brown.

39. *Pig-Weed*. About one-twenty-fourth of an inch in length; flattened, egg-shaped, or lens-shaped; polished and jet black; a slight notch on sharp edge is the scar; near the scar-notch is a small projecting point.



The small drawings beside the enlarged drawings represent the natural side of the seeds.

A small magnifying glass is very useful in identifying seeds. Perhaps the most convenient glass for the purpose is the *tripod magnifier* (Fig. A), costing about fifty cents. The *linen-tester* (Fig. B) is cheaper, but yet quite serviceable.

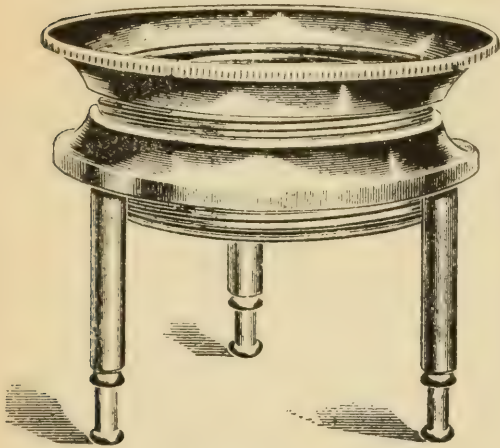


Fig. A. Tripod magnifier.

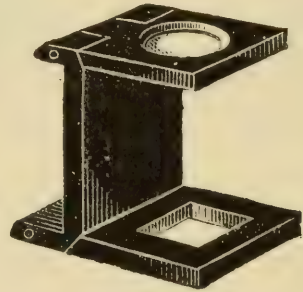


Fig. B. Linen tester.

CLASSIFICATION OF WEEDS.

Weeds may be classified according to the length of time they live, as follows:

Annuals, or weeds which germinate, bloom, fruit, and die, in one year or season. Corn Cockle is an example.

Winter Annuals, which germinate late in summer or autumn, pass the winter as seedlings or immature plants, and complete the cycle of their existence by blooming, fruiting, and dying during the following summer. Such are Chess and Shepherd's Purse.

Biennials, which produce leaves and roots the first year, and flowers and seeds the second year, after which they die. The Wild Carrot and Evening Primrose are familiar examples.

Perennials, which last from year to year, blooming and seeding annually. These are divided into two classes:

(1) Those with underground creeping stems, such as the Canada Thistle.

(2) Those with roots which do not spread underground, such as Chicory and Plantain.

It is important to know the class to which a weed belongs, as the method of eradicating an annual is often very different from that required to destroy a perennial.

ERADICATION OF WEEDS.

The most important points under this head are :

First, a determination to get rid of weeds and to keep the land clean.

Second, the method or methods of tillage and cropping.

As regards the latter point, the writer feels that he cannot do better than submit the method outlined by our late Farm Superintendent, Wm. Rennie, whose experience of over thirty years warrants him in speaking with some confidence on the subject. Mr. Rennie's method not only cleans the land but increases its fertility, and those who wish fuller information should consult the college reports for 1895, 1896, and 1897.

For various reasons, very few farms in the older sections of the Province of Ontario are free from weeds, and the question how to clean our lands without incurring too much expense is one of the most important which can engage the attention of Canadian farmers.

In the first place, I would say that all obstructions to cultivation, such as piles of stone, must be removed—hailed away to the woods or an out-of-the-way corner in the winter or some other slack time. Secondly places for harboring weeds, such, for example as snake fences, should be got rid of as soon as possible. On the Ontario Experimental Farm, nearly all field fences have been removed. The outside and lane fences are almost the only ones left. Portable fences are used when required for pasturing live stock.

Annuals and Biennials. Wild oats, wild mustard seed, and some other seeds belonging to these classes, have great vitality. If down pretty well beyond the reach of the air, they will live for twenty years, and will germinate as soon as they are brought near the surface.

The best way to destroy annuals and biennials is by thorough and frequent shallow cultivation, early after harvest in stubble ground and in sod plowed for the following year, and at the proper season (spring and summer) among what are called "hoed crops" that is, potatoes, carrots, turnips, mangels, Indian corn, etc. By shallow cultivation the seeds are kept near the surface, and by frequent stirring of the soil they are made to sprout; and having sprouted, they can be killed by further cultivation. Those which sprout late in the fall are destroyed by the winter frost. It is impossible to get rid of such weeds by plowing the ordinary depth, say seven or eight inches, once in the fall or at any other time. Plow shallow (not more than four inches in sod and three inches in stubble ground), and harrow and cultivate from frequently, as by each stirring of the soil fresh seed is made to sprout and what has already sprouted is destroyed. When necessary to loosen the soil to a greater depth, use a grubber or a subsoil plow.

Perennials. It is necessary to study the habits of perennial weeds to see how they grow and propagate themselves from year to year, in order to keep them in check; and a close examination of almost any of them will show that the buds from which the young plants start are near the surface of the soil. Hence shallow cultivation, similar to that mentioned above, is the effective method of destroying them. Deep plowing only transplants the buds to a greater depth and increases the trouble. Plow shallow (see preceding paragraph), and harrow and cultivate frequently, using a grubber or subsoil plow when it is necessary to stir the soil to a greater depth. As above, the cultivation must be early after harvest and throughout the fall in stubble ground and sod, and in spring and summer among corn, potatoes, and root crops. Ill-timed, irregular or partial cultivation only makes all weeds grow more vigorously.

Canada thistles, sow thistles, couch-grass, bindweed, etc., can be destroyed by the following method. Middle of May gang plow the land about three inches deep and harrow thoroughly. In two weeks, when the weeds are nicely up, cultivate with a common or spring-tooth cultivator provided with wide points that overlap so as to cut off every plant two or three inches below the surface. Then harrow to pull up the plants and leave them die. In the middle of June, there will be another crop, and possibly a greater number of plants, but not so vigorous as the first crop. Repeat the operations with the wide point cultivator and the harrow. In July a few delicate plants will make their appearance and will have to be destroyed in the same way. This will be sufficient for most weeds; but bindweed may need one or two extra cuttings with the wide points and a corresponding number of harrowings.

The preceding method will clean the land, but it involves the loss of a year's crop; so it is well to add, that land may be kept comparatively free from weeds without the loss of a crop, by after-harvest cultivation of all fields not in grass, begun with each field *just as soon as the crop is off* and continued throughout the fall, first by shallow gang-plowing and harrowing and afterwards at intervals, as above, by the wide-point cultivator and the harrow. This treatment followed by a hoed crop *properly attended to* will destroy most perennial weeds and all annual and biennial seeds that are near the surface.

Note. To Mr. Rennie's method or methods, as above given, I would venture to add one which we have seen carried out with the most satisfactory results by Mr. Rennie on the College farm, and with marked success by farmers in other parts of the Province. It may be put in the imperative form, as follows: Sow much with red clover, in order to have a rich clover sod to plow down for all or nearly all spring crops, taking as far as possible only one crop of hay or pasture

before plowing, occasionally two, but not more than two. Plow the clover sod shallow, not more than four inches, early after harvest, say the 1st to the 15th of August, and harrow at once. Let it stand a couple of weeks; then cultivate, the same way as it was plowed, two or three inches deep, with a spring-tooth cultivator. After a while, cross cultivate a little deeper. If possible, cultivate a third, or even a fourth time, going a little deeper each time. Then, if you can manage to do so, rib it up with a double mouldboard plow, as you would for a crop of turnips. When this is done the available plant food (clover roots, etc.) is preserved in the center of the drills, the water runs off early in the spring, and the drills can be levelled with the cultivator and harrow, either for spring grain or for hoed crops.

This method will not only clean land but will greatly enrich it.

INFORMATION FROM FARMERS AS TO NEW WEEDS, ETC., IN DIFFERENT PARTS OF THE PROVINCE.

At the request of the writer, the Ontario Department of Agriculture, in 1898, kindly sent out a few questions about weeds to its regular correspondents, and others, chiefly those who had done satisfactory experimental work in connection with the Experimental Union. A large number of answers were received, and as part of the information contained therein is not given elsewhere in the bulletin, some of the answers are briefly referred to below. The questions were as follows:

1. *What is the character of the soil in your township?* This was to ascertain what species of weeds grow most abundantly in certain kinds of soil.

2. *Are the weeds in your neighborhood more numerous and more troublesome than they were ten years ago?* The majority of the correspondents say that weeds are far more numerous than they were, and that the injury done by them is far greater. The Canada Thistle, however, is spoken of as much less troublesome than it was, —a fact due, no doubt, to the vigorous methods taken to eradicate it from cultivated land, and in a less degree to the law for its destruction on the highways.

3. *Are the provisions of the weed law enforced in your township?* About 95 per cent. answer *No* most emphatically. They say that a number of townships appoint men to look after the Canada Thistle, but that little or nothing is done with other weeds. "The township council takes no action, because the councillors are afraid of losing votes at the next election." "Pathmasters do not enforce the Act, for fear of incurring the enmity of neighbors;" and "rented farms, especially such as belong to loan companies, are often overrun with weeds, to the great injury of neighboring farmers."

4. *What is the estimated annual loss which you sustain from weeds?* Some of the answers to this question are amusing, but the great majority of them show a full appreciation of the fact that a serious loss undoubtedly results from the existence of weeds among farm crops.

Some consider the weeds a blessing in disguise, as they compel lazy and careless farmers to keep on cultivating the soil; and very many, in making their estimate, seem wholly to overlook the loss from the use of plant food and the absorption of soil moisture by weeds. A number estimate their loss at twenty-five cents per acre, and quite a few place it as high as \$5 per acre; so, considering the whole list and counting labor, with the loss of soil moisture, fertility, etc., we think that \$1.00 per acre is a conservative estimate of the annual loss throughout the Province.

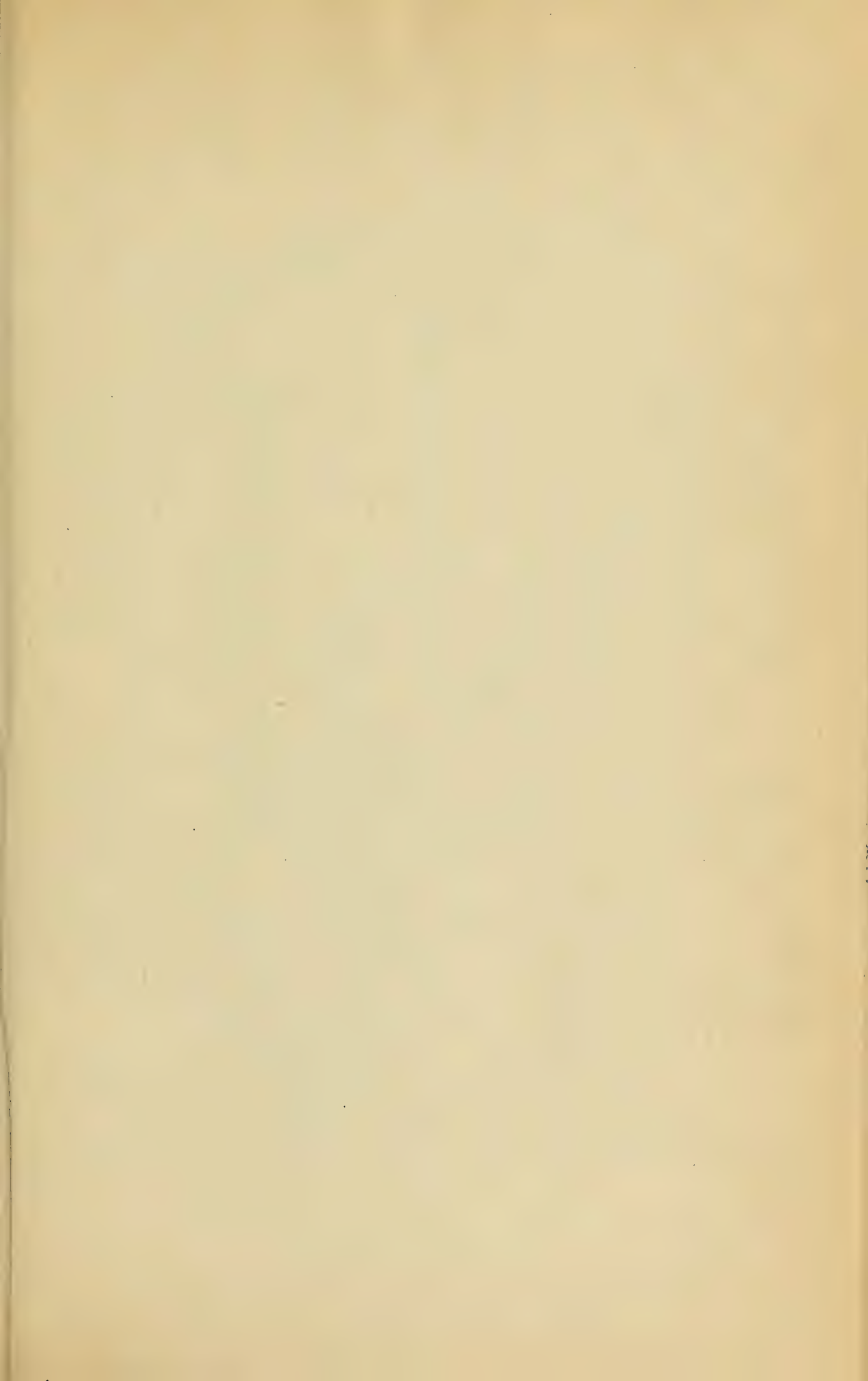
5. *What means do you use to destroy the weeds on your farm? and with what success?* Many full answers were given to this question; and the most valuable information contained in these answers has been set forth under various heads in the descriptions which follow. One point, however, which is strongly emphasized by many, may be mentioned in passing, viz., that no method, however good it may be, is of any use, unless it is faithfully carried out. A lack of thoroughness in the work done for the destruction of weeds always results in failure.

6. *What new weeds have you noticed lately in your locality? Are they spreading rapidly? and how have they been introduced?*

As to the ways in which the above weeds have been introduced, the answers are various, but the great majority of the correspondents mention two agencies as chiefly responsible: (1) Impure seed, especially grass and clover seed; (2) Threshing machines.

Several grades of clover seed are sold by seedsmen:—No. 1, or the best quality, is usually clean, but most of it is exported, as Canadian farmers will not pay the price asked for this grade; No. 2, or second quality, is the kind generally sold in country stores throughout the Province. Of the samples referred to on a previous page as having been examined by us, by far the worst were from country stores, for which fact we cannot say that the storekeepers are to blame any more than the farmers who refuse to pay the price necessary to secure the best seed.

We would again urge that every farmer, no matter what the assertions or statements of sellers may be, should examine carefully with a glass all grass and clover seed which he thinks of sowing on his land; and in case he discovers foreign seeds which he does not know, let him send samples to the Ontario Agricultural College, Guelph, and all such samples will be promptly examined and reported upon.



A NUMBER OF COMMON WEEDS, WITH POPULAR DESCRIPTORS AND NOTES ON ERADICATION.

FIG. 1.

FOX-TAIL. YELLOW FOX-TAIL, BOTTLE GRASS, OR PIGEON GRASS.

Chameraphis glauca (L).

A common weed in stubble, fallow or root fields. It has a perennial root, with stems about two feet high, of erect habit of growth. At the summit of that part of the leaf which sheaths the stem (the ligule) there is a fringe of hairs. The leaves are flat, rough above, and smooth beneath. The dense, close spike, which resembles millet, is bristly and tawny yellow in color.

The seeds are $\frac{1}{8}$ in. long, various shades of brown in color, with transverse wrinkles. They frequently retain their green color, and are quite commonly found as an impurity in clover and grass seed. (See Fig. 1, a.) An average plant produces about 15,000 seeds.

Time of flowering, July-September.

Time of seeding, August-October.

Eradication. Gangplow stubble ground about three inches deep early in the fall; as soon as the seeds have had time to sprout, cultivate thoroughly; repeat cultivation and rib the land with a double mould board plow the last thing before the frost. Put in a hoed crop (potatoes, roots or corn) next spring and cultivate thoroughly throughout the growing season. Follow with a grain crop seeded with clover, without plowing after the roots, for if the land is plowed it is liable to bring more seed to the surface. When the sod is broken up, plow shallow in the latter part of harvest, cultivate with harrow and cultivator throughout the fall, and rib up as above.

In the early after-harvest cultivation of stubble ground, some harrow the stubble as the first step; and when the weed seeds have sprouted under their light covering, then gang-plow and harrow, and stir afterwards with the cultivator as time permits throughout the fall.



FIG 1.
YELLOW FOX-TAIL.
(*Chameraphis glauca*).

FIG. 2.

CHESS, CHEAT OR WHEAT THIEF.

Bromus secalinus (L).

A weed naturalized from Europe. It is a winter annual, with fibrous roots and rough coarse leaves. It has large spikelets, dark green in color, of characteristic shape, and grows from three to four feet high.

Many look upon Chess as degenerated wheat, because it appears among fall wheat that has been winter-killed. This idea is erroneous and without foundation. The fact is that Chess will mature seed under adverse conditions, even though the plant be only a few inches high. The seed possesses great vitality, and is often found in wheat and rye.

Chess is most commonly found among wheat and rye.

The flour made from it is dark-colored and has narcotic principles. Care in the selection of seed grain and careful cultivation, tending to prevent the maturing of the seeds, are the chief remedies. The planting of a crop that can be harvested before the Chess matures is a good plan in badly infested localities. An average plant produces about 1,000 seeds.

Time of flowering, June. Time of seeding, July.

"Chess is a typical plant belonging to the genus *Bromus*. Wheat belongs to the genus *Triticum*. Chess will produce Chess and only Chess, and a seed of wheat cannot be sown to produce Chess, and Chess cannot produce wheat under the most favorable conditions of growth.

"In instances where parts of a plant, apparently a combination of Chess and wheat were so united as to seem but one plant, close examination proved them to be parts of separate plants, and that the apparent union was not real."

Eradication. Avoid fall sown crops, and follow as far as practicable the same method as is recommended for Mustard. In this case, however, the meadow will require special attention, and any weeds that appear must be removed. If many weeds appear in the meadow, it will be better to break it up and follow the rotation suggested under Fox-tail.

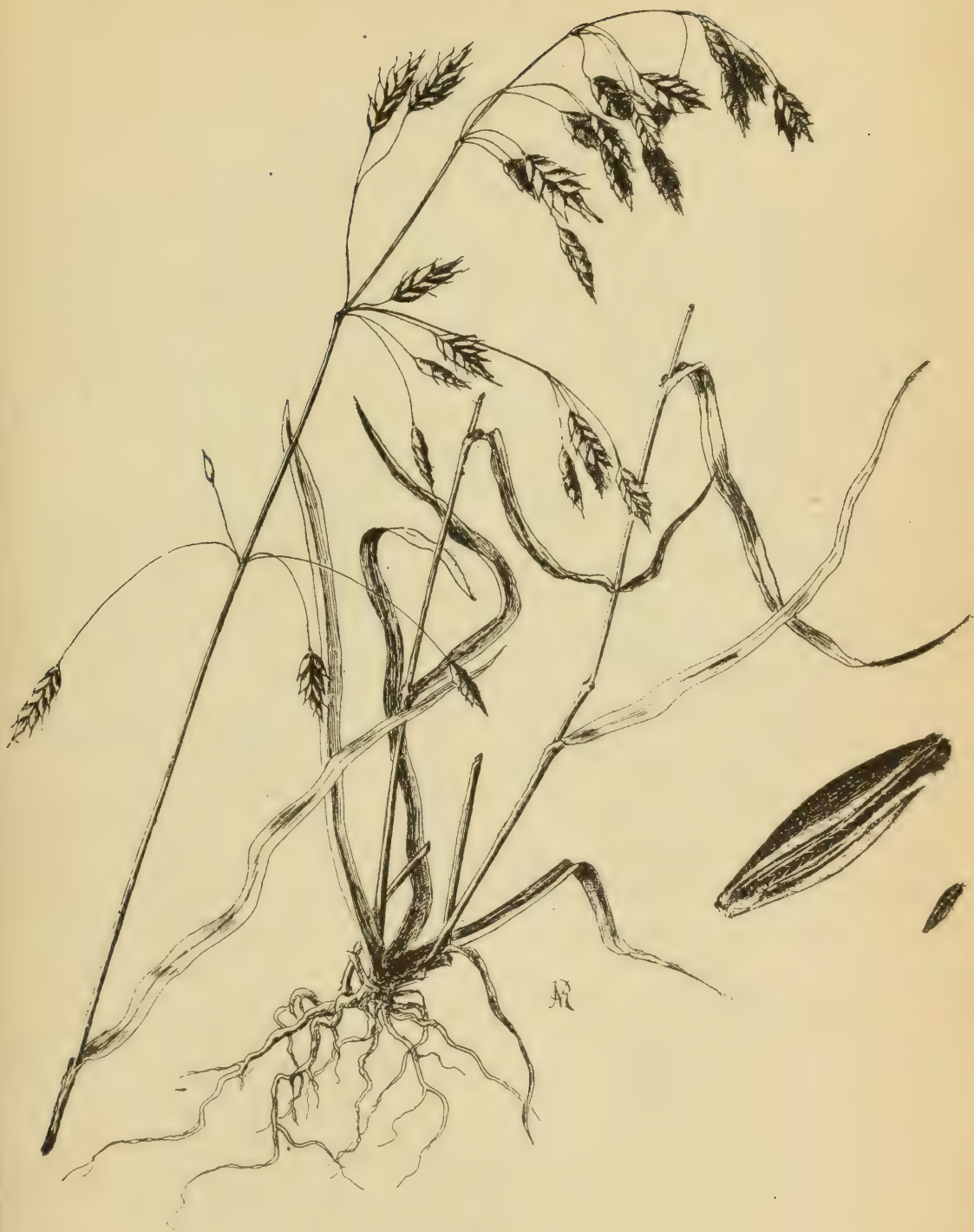


FIG. 2.
CHESS.
(*Bromus secalinus*.)

FIG. 3.

WILD OAT.

Avena fatua (L).

An annual weed with erect and smooth stems. The leaves and stems are covered with white bloom, which give a peculiar white-green color to the whole plant. The head forms a loose panicle, with nodding and spreading branchlets. The awn is long and bent, and covered with brown hairs. It is bent most when dry; but if moistened, it uncoils and wriggles around, thus causing the seed to move appreciable distances.

The principal points of differences between the wild and cultivated oats are (1) In the former the chaff is thick and hairy, while in the latter it is thin and hairless; and (2) The wild oat has a long, stiff awn which is bent and twisted when dry, while the cultivated oat either has a much smaller and less stiff awn or none at all. An average plant produces about 800 seeds.

Time of flowering, July. Time of seeding, July-August.

Dispersal—conveyed from place to place by threshing machines, and as an impurity in seed-grain.

Wild oats are at home in any soil that will grow cereals, and they ripen their seeds among almost any cereal crop. The seeds possess wonderful vitality, some of them remaining buried in the soil for years and germinating as soon as they are brought under favourable conditions.

Eradication. On a field infested with wild oats, cereal crops should be dropped out of the rotation as far as possible; and hoed crops, soiling crops, hay, and pasture should take their place. To get the land under grass, it should be fallowed during part of the season, the cultivation being frequent and shallow, to destroy all seeds that may have germinated in the upper layer of the soil. The land can then be sown with winter wheat and seeded, or with an early variety of barley, which should be cut on the green side. The treatment mentioned is suitable for pasture land, or land which has produced a hay or soiling crop during the forepart of the season.

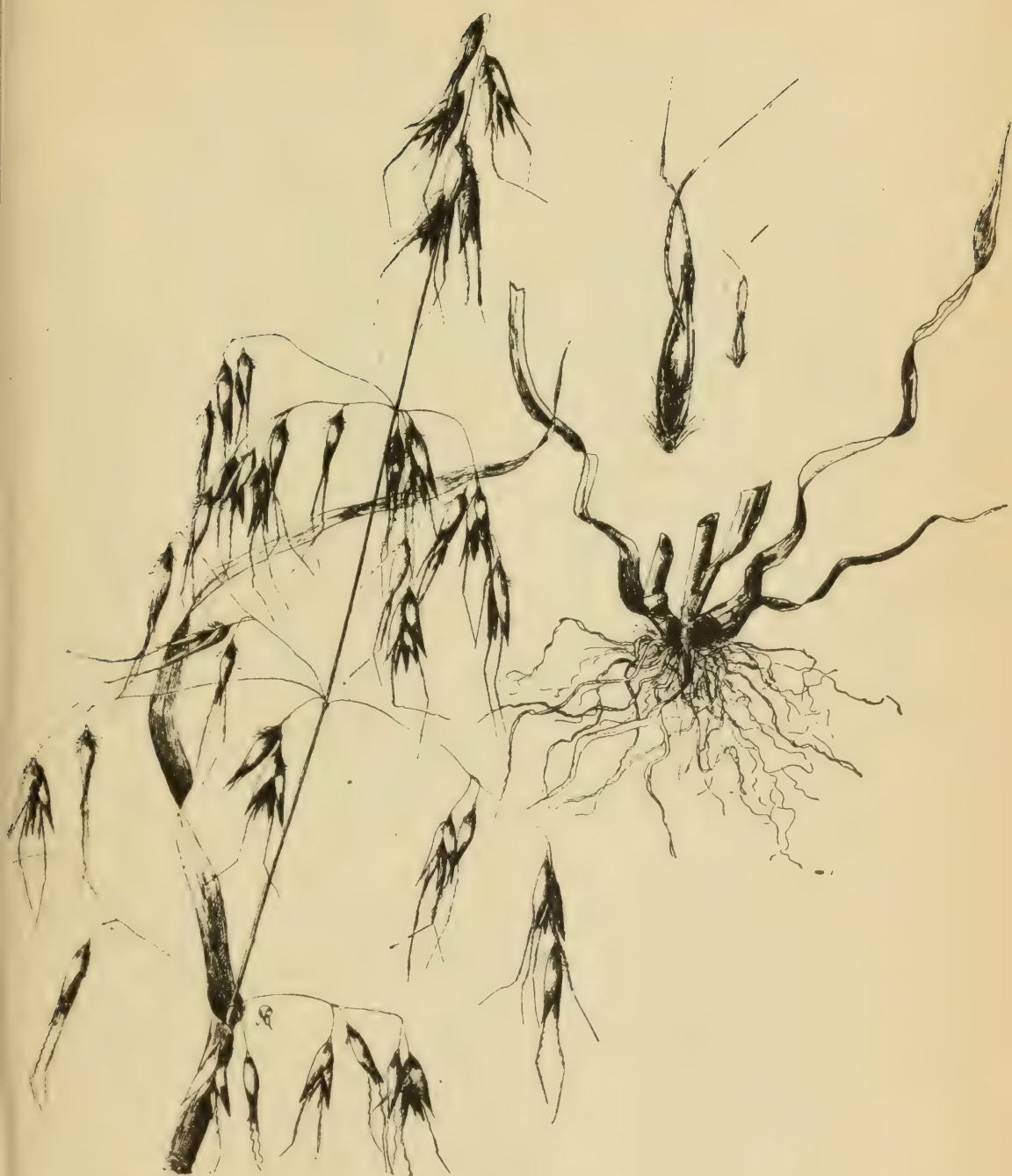


FIG. 3.
WILD OAT.
(*Avena fatua*.)

FIG. 4.

COUCH-GRASS, TWITCH-GRASS, QUACK-GRASS, QUITCH-GRASS, OR QUICK-GRASS; ALSO WHEAT-GRASS.

Agropyron repens (L).

Couch-grass is a creeping perennial which grows from 1 to 3 feet high. It has a jointed root-stock which penetrates deeply into the ground and possesses great vitality. The plant produces spikes from 3 to 8 inches long. The small spikelets alternate at each notch of the flower stalk, with the side of the spikelet turned towards the stalk.

The seeds are about $\frac{1}{2}$ in. long, and rather slender (Fig 4. a.). An average plant produces 400 seeds.

Time of flowering, June-July.

Time of seeding, July-August.

Dispersal—the root-stocks are carried around by implements and the seeds are occasionally found in seed-grain.

Whatever value Couch-grass may have for pasture, its habit of taking and keeping possession of the soil renders it extremely objectionable. It flourishes best in loamy or humus soils, from which it is especially difficult to eradicate.

Eradication. As soon as the crop is harvested plow lightly, then harrow with the ordinary harrow, and if necessary cultivate with the spring-tooth cultivator. This shakes the roots free from the soil and makes it possible to gather them up with the horse rake. Burn as soon as they have dried sufficiently. Repeat this process two or three times. If the weather at this time should happen to be dry and hot, so much the better. Late in the fall, rib up the land into drills and allow to stand over winter. The frost in all probably will render material assistance in the eradication. The following spring, plow about the end of May, cultivate well and put in some hoed crop, or summer fallow, sowing buckwheat, the crop to be plowed in. A carefully cultivated crop of rape is recommended as being particularly effective in destroying this pest.

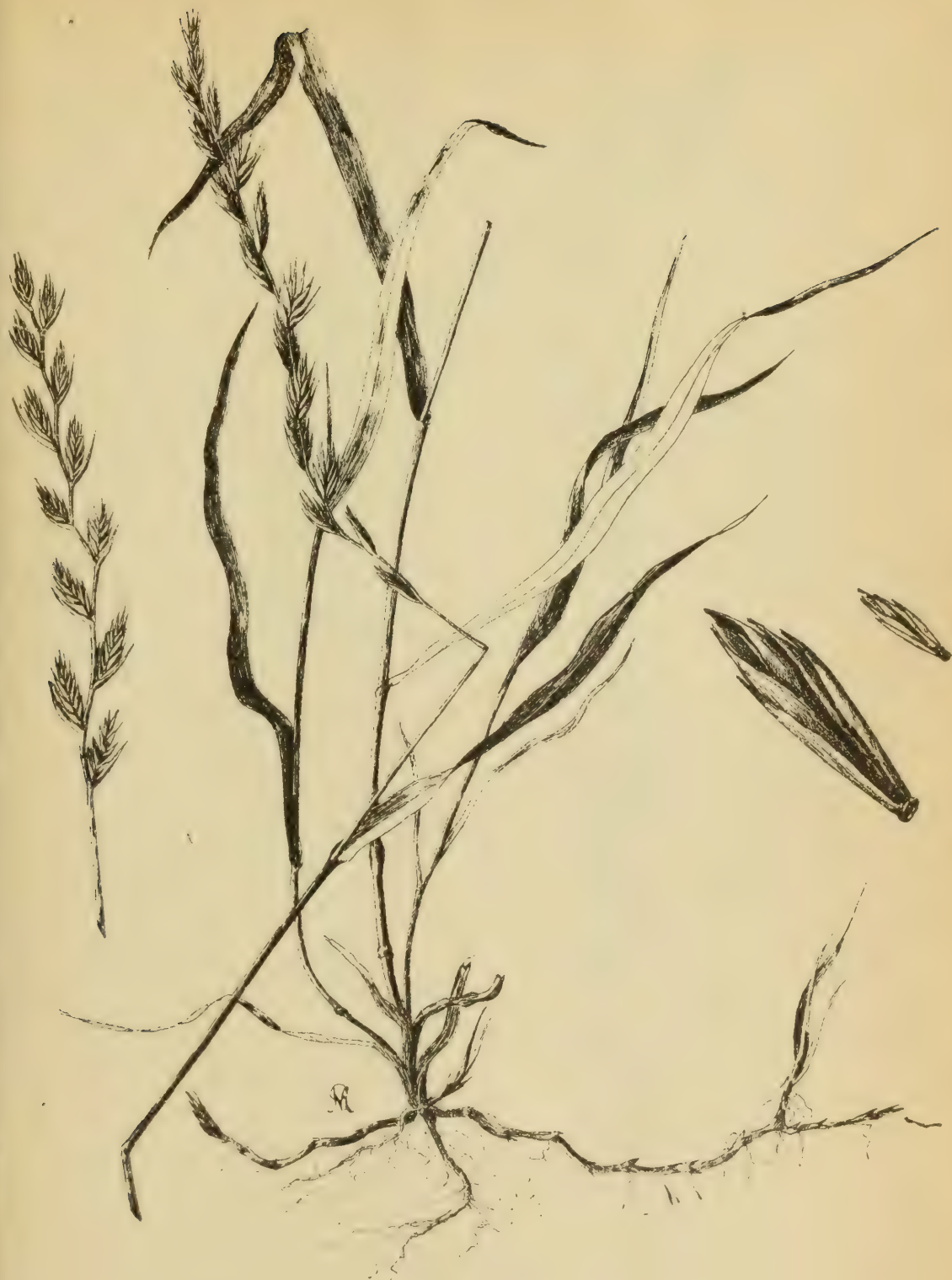


FIG. 4.

Couch Grass on right of figure and part of a stalk of *perennial rye-grass* (*Lolium perenne*) on left. Note the arrangement of spikelets in rye-grass.

FIG. 5.

DOCK, CURLED DOCK, SOUR DOCK, OR YELLOW DOCK.

Rumex Crispus (L).

A deep-rooted perennial weed introduced from Europe.

It occurs around buildings, in neglected lanes, along waysides and in pastures. The stem is quite slender, and the leaves are from six to twelve inches long, with wavy margins; hence the common name, "curled dock." The flowers are in racemes, green in color.

The seed is winged, and is carried considerable distances by the wind. The manner of attachment of the seed to the wing is shown in illustration (Fig. 5, a.). The seeds are light brown in color, triangular, with sharp edges and tapering point. They are smooth and shiny (Fig. 5, b).

The wind acts as an agency in scattering the seed, and it is a very common impurity in clover and other seeds used on the farm.

An average plant produces about 17,000 seeds.

Time of flowering and seeding, July-August.

Eradication. In most cases this weed can be kept in check by the frequent introduction of well-cared-for hoed crops into the rotation. The shorter the rotation, the better. The later sown hoed crops, especially rape, are more effective than those sown earlier in the season. Before the hoed crop is sown, this weed may be kept from breathing above ground by going frequently over the field with a broad-shared cultivator, which will cut the plants an inch or two below the surface; but as the roots are tough and strong, it may sometimes be necessary to use the gang-plow, or even the single plow. About the 1st of July, the land may be sown with rape in drills, say 26 inches apart, and kept clean, or nearly so, by the horse-hoe and more or less hand hoeing. The rape can be pastured off in the usual way during the fall; and occasionally it may be necessary to put another hoed crop on the same ground the following spring, say a crop of corn; but much depends upon the timeliness, regularity, and thoroughness with which the hoeing is done.



FIG. 5.
CURLED DOCK.
(*Rumex crispus*)

FIG. 6.

SORREL, OR SHEEP SORREL.

Rumex Acetosella (L).

A perennial with running root-stocks. The stem is slender and erect with branches. The leaves are spear-shaped and quite characteristic. The flowers occur in racemes and are green in color. The foliage has a pronounced acid taste.

The seed is 1-16 in. long, triangular, smooth, and shining when naked, but dull brown when invested by its covering. An average plant produces about 10,000 seeds.

Time of flowering June-September.

Time of seeding, July-October.

Propagation—by its running root-stocks, and as an impurity in clover seed, especially Alsike.

Eradication. Sorrel is usually an indication of a poor, sandy, or gravelly soil. It prefers acid soils, hence liming and manuring are effective remedies when the land is well tilled. The remedies given for the Dock (Fig. 5) are applicable to Sorrel, only it requires more frequent use of the broad shared cultivator, which should be used so as to cut the roots just below the surface of the soil, without bringing up any of the creeping root-stocks.



FIG. 6.
SHEEP SORREL.
(*Rumex acetosella*.)

FIG. 7.

LAMB'S QUARTERS, OR GOOSEFOOT.

Chenopodium album (L.).

An annual weed widely distributed in cultivated land. It grows to a height of from 2 to 6 feet. The stem is grooved and much branched. The leaves are whitish green below and dark green above. The flowers are inconspicuous and greenish in color.

The seed (Fig. 7, a.) is black and shining, lens-shaped and round, about 1-16 in. in diameter.

Time of flowering, June-October.

Time of seeding, August-October.

Distribution—by seeds, especially as an impurity in clover and grass seeds.

Eradication. Late cultivation is especially necessary in combating this weed, as it flowers and seeds till very late in the season. The land should be gang-plowed shallow and harrowed immediately after harvest, and cultivated at intervals until late in the fall, when it may be plowed or ribbed up for a hoed crop the following spring. Subsequent treatment the same as for Foxtail (Fig. 1.)



FIG. 7.
LAMB'S QUARTERS.
(*Chenopodium album.*)

FIG 8.

PIGWEEED, OR REDROOT

Amarantus retroflexus (L).

An annual, with pink root, stout, erect stem, and many branches. It grows from 1 to 6 feet high. The leaves are light green in color, and ovate in shape. The flowers are in spikes, which terminate branches, or are from the axils of the leaves, and are green in color.

The seeds (Fig. 8, a) are round and lens-shaped, smooth and shiny black in color, resembling the seed of Lamb's Quarters, but slightly smaller and thinner. An average plant produces 15,000 seeds.

Time of flowering, July-September.

Time of seeding, August-October.

Dispersal—the seed is distributed by the wind and as an impurity in grass seed.

Eradication. Special attention must be given to fall cultivation of the soil, so as to prevent plants from ripening, and to sprout and destroy the seeds which have fallen upon the ground. The land should be gang-plowed shallow and harrowed immediately after harvest, and cultivated at intervals until late in the fall, when it may be plowed or ribbed up for a hoed crop the following spring. Subsequent treatment the same as for Foxtail (Fig. 1).



FIG. 8.
PIG-WEED.
(*Amarantus retroflexus*.)

FIG. 9.

PURSLANE, OR PURSLEY.

Portulaca oleracea (L).

Purslane is pre-eminently a garden weed and is readily recognized by its fleshy leaves and stem, which lie prostrate on the ground. It is an annual.

The stems are red, and the leaves wedge-shaped and clustered at the ends of branches. The flowers are bright yellow, about $\frac{1}{4}$ in. across and open only during full sunlight for a few hours in the morning. The seeds (Fig. 9, a), in small capsules, are black, kidney-shaped, and extremely small. An average plant produces 60,000 seeds.

Time of flowering, July, until frost.

Time of seeding, August, until frost.

Dispersal—by seeds.

Purslane has been used as hog feed in very dry seasons, but the cost of gathering it is too great.

Eradication. Careful hoeing and constant cultivation. The latter should be as early as possible. The same treatment should be followed as that outlined for Foxtail (Fig. 1).

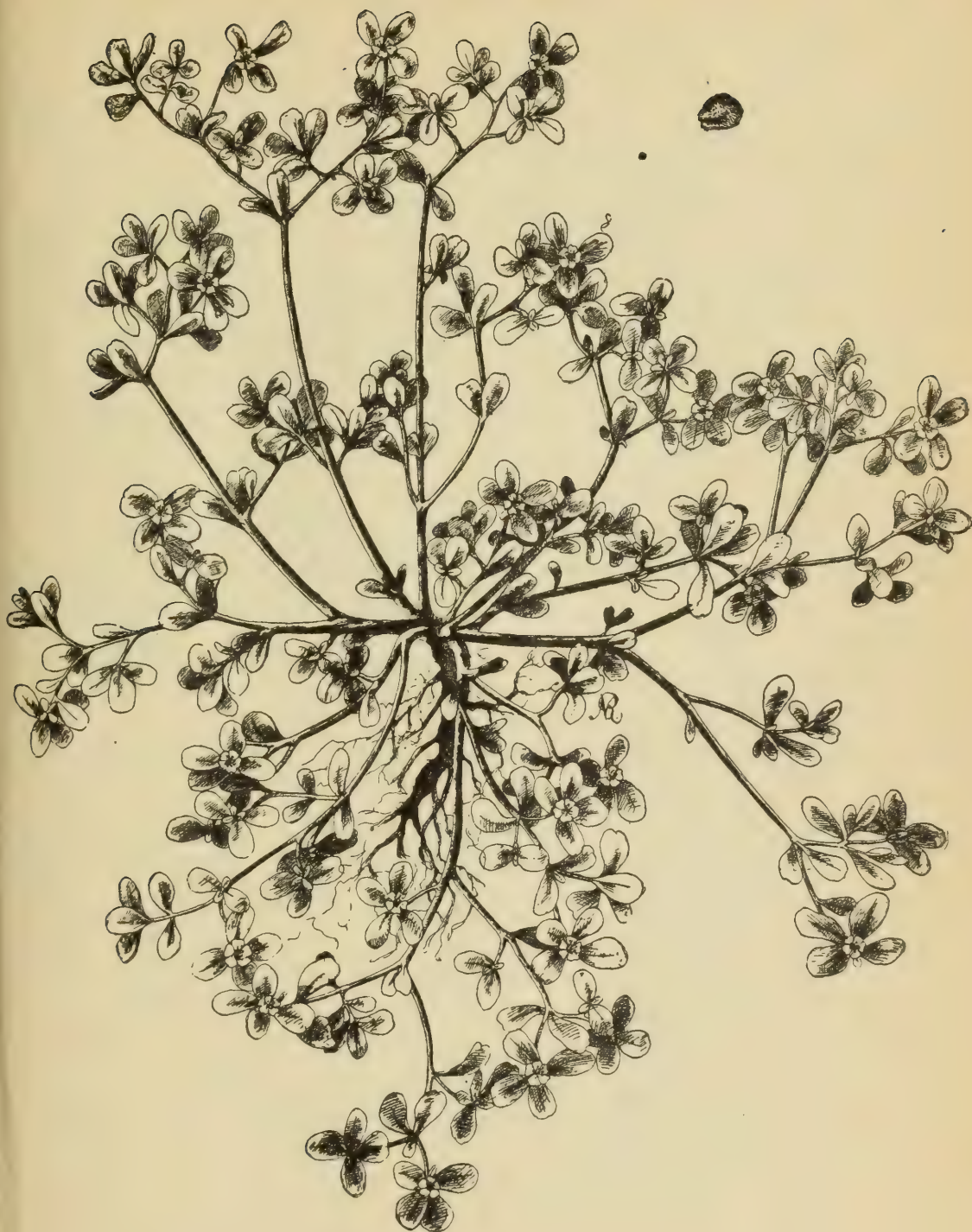


FIG. 9.
PURSLANE.
(*Portulaca oleracea.*)

FIG. 10.

CORN COCKLE, OR CORN CAMPION.

Agrostemma githago (L).

An annual adventive from Europe, about 1 to 3 feet high, with erect habit of growth. It has but few branches, and the stems are all very hairy, with whitish-green hairs. The leaves are rather long and narrow, with pointed ends. The flowers are red to purple, and the flower cup (calyx) has long lobes, three or four times the length of the petals.

The seed capsules are generally well filled with seed which is black in color and kidney-shaped, with tubercles (small conical projections) arranged in rows around the sides of the seed. (See Fig. 10, a.) The seed is about $\frac{1}{8}$ in. across. An average plant produces about 500 seeds.

Time of flowering, July.

Time of seeding, August.

Dispersal—by birds, in manure, and as an impurity in seed again.

It may be noted, in passing, that the seed is injurious to young chickens, and the husks of the seed often elude the miller and appear as black specks in flour, which is seriously damaged thereby. An old writer, Gerarde, says :

“What hurt it doth among corn (wheat) the spoyle unto bread, as well in colour, taste, and unwholesomeness, is better known than desired.”

Eradication. Sow clean seed ; and when the weed is not very thick pull it by hand. Otherwise use the same treatment as for mustard. (See Fig. 15).

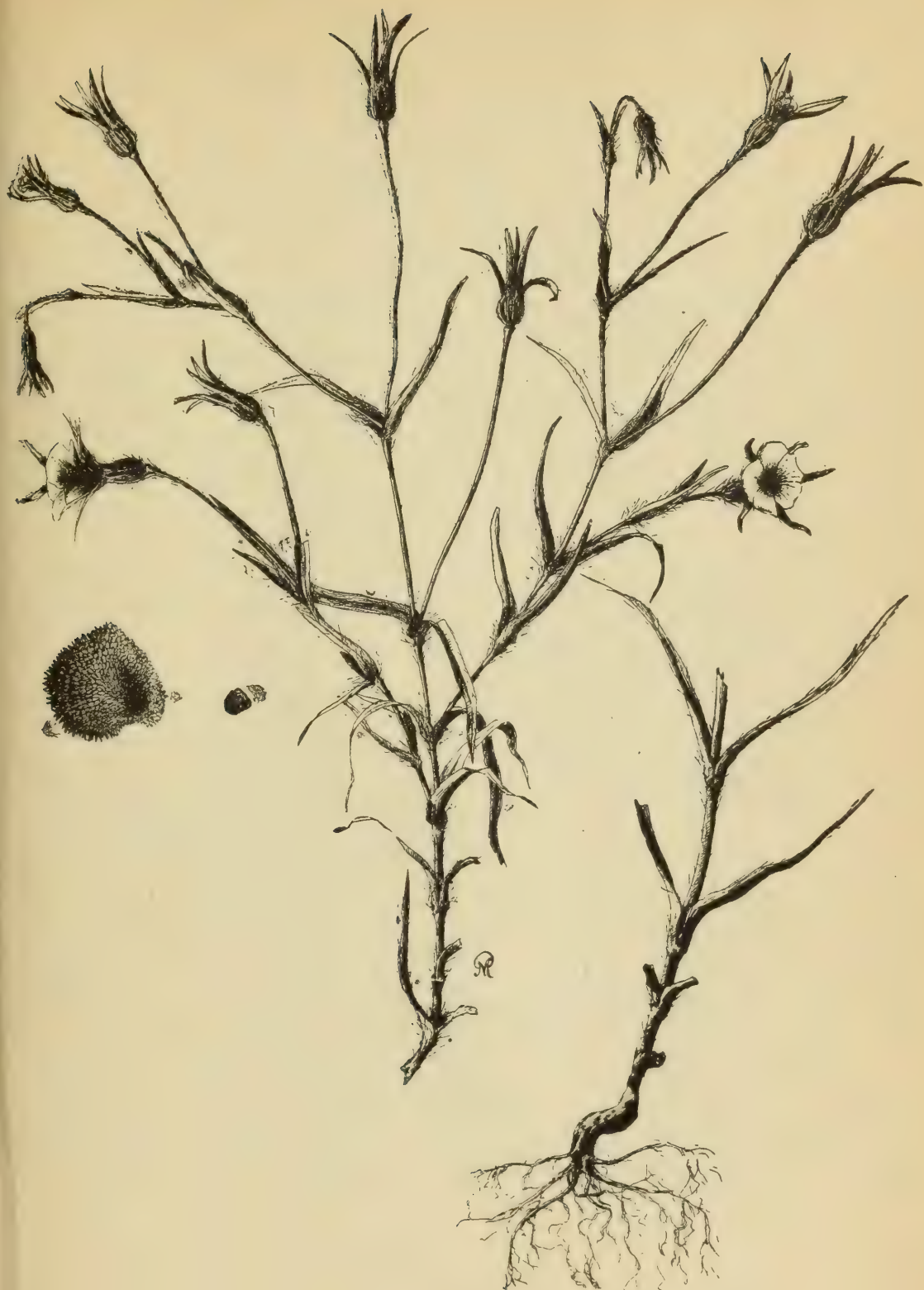


FIG. 10.
CORN COCKLE.
Agrostemma githago.

FIG. 11.

BLADDER CAMPION, OR COW BELL.

Silene inflata (L).

A naturalized perennial which promises to be a bad weed in Ontario ; and it is spreading very fast. It grows from 6 inches to 2 feet in height, and branches from the base. The leaves are oblong and vary greatly in size. The flowers are white, about $\frac{1}{2}$ in. broad, and are arranged in a loose panicle. The flower cup (calyx), veined and inflated like a bladder, distinguishes the plant from others that resemble it.

The seeds are brown and kidney-shaped, with minute tubercles disposed regularly over the surface (Fig. 11 a). An average plant produces about 9,000 seeds.

Time of flowering, June-August.

Time of seeding, July-September.

Dispersal—by root-stocks and as an impurity in seeds.

The Night-flowering Catchfly (*Silene Noctiflora*), resembles the Bladder Champion ; but it is an annual, tall and very leafy, with a viscid secretion all over its stem, often so profuse that the stems and leaves are covered with small insects entangled in it. It opens at night and possesses a fragrant smell. It is not so bad a weed as its relative, the Bladder Champion. In Fig. 11 are shown the seeds of these two plants, natural size and enlarged. That on the left is Bladder Champion, that on the right is the Night-flowering Catchfly.

Eradication. For these weeds practically the same treatment as outlined for the creeping perennials (Canada Thistle, etc.) will answer, although the plow may have to be resorted to more frequently, instead of the broad-shared cultivator, on account of the size and thickness of the roots.

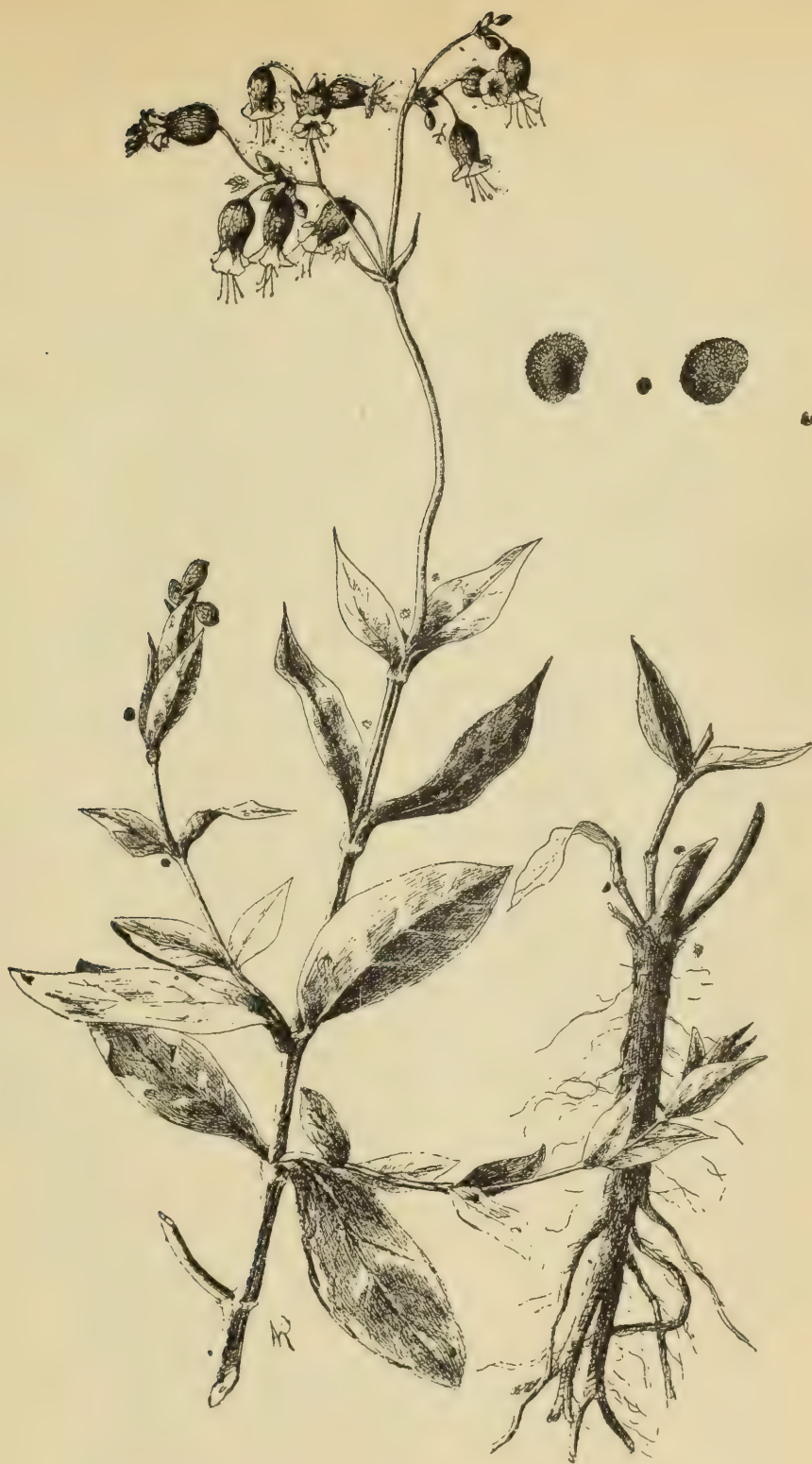


FIG. 11.
BLADDER CAMPION.
(*Silene inflata*.)

FIG. 12.

WHITE CAMPION, OR WHITE COCKLE.

Lychnis alba (L).

A biennial weed introduced from Europe, with hairy and branching stems from 1 to 3 feet high. Like the Night-flowering Catchfly it has a viscid secretion, which attracts many insects. The leaves are oblong, with acute tips. The flowers are in loose panicles, white or pink in color, and nearly $\frac{3}{4}$ in. broad. As a rule they open at night and remain so until the morning of the following day. The pod has short teeth around the top, which curl back when dry, and the seeds are distributed by the winds swaying the stem, when the seeds drop out. In wet weather these teeth straighten out and completely close the opening at the top.

The seed (Fig. 12, a) is brown in color and kidney-shaped, with tubercles regularly disposed over the surface. An average plant produces 10,000 seeds.

Time of flowering, June-August.

Time of seeding, July-August.

Dispersal—by wind and as an impurity in seeds.

Eradication. Exercise great care in cleaning seed grain, and examine all purchased grain with a sharp lookout for this seed. If the weed be on the farm, follow the method outlined for Foxtail (Fig. 1) or Mustard (Fig. 15).

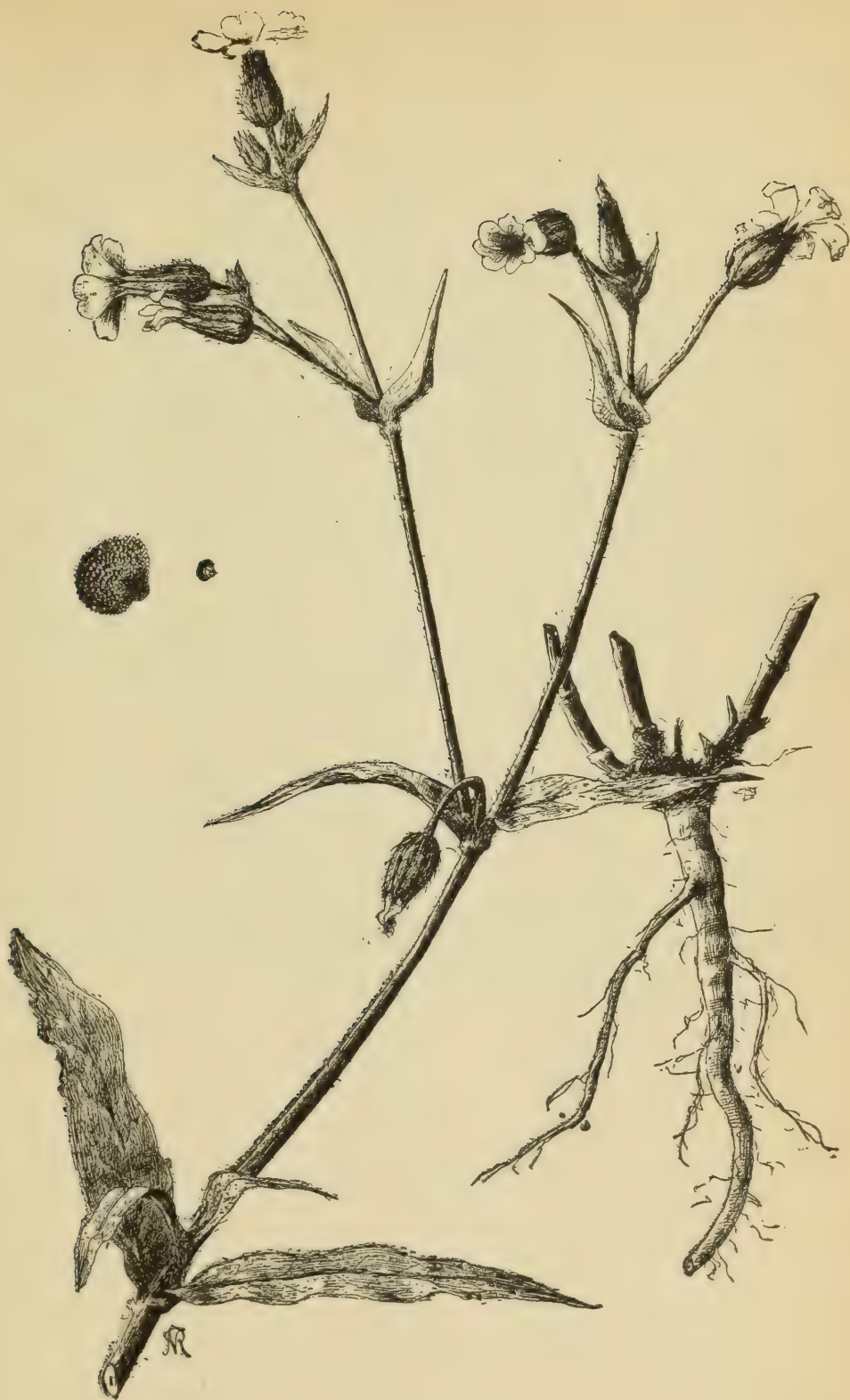


FIG. 12.
WHITE COCKLE.
(*Lychnis alba*.)

Fig. 13.

PEPPER GRASS, OR TONGUE GRASS.

Lepidium Virginicum (L).

A native annual which grows from six inches to a foot and a half high. The stem usually has many branches, and the lower leaves terminate in a large lobe (with small lateral ones), with edges slightly cut in along the margin. The upper leaves are tapering. The flowers are small and white, with slender spreading flower stalks. The seed pods are round, with a very small wing at the top and a notch at the extremity. The end of a branch with seed pods is shown nearly natural size in Fig. 13, a.

The seeds (Fig. 13, b) are reddish brown, flat and oval in shape, and 1-1½ in. long. The average plant produces about 18,000 seeds.

Time of flowering, June-August.

Time of seeding, July-September.

Dispersal—by birds and as an impurity in clover seed.

Eradication. Be careful to prevent the plants from seeding, and do not plow them under when half ripe, as many of the seeds will germinate even though partially matured. Pull and burn where only a few plants exist, and when they are numerous use the method employed for the eradication of Mustard (Fig. 15).



FIG. 13.
PEPPER GRASS.
(*Lepidium Virginicum*.)

FIG. 14.

PENNY-CRESS, BASTARD-CRESS, FRENCH WEED, WILD GARLIC, OR
STINK-WEED.

Thlaspi arvense, (L).

A winter annual, introduced from Europe, and a very bad weed. It is very abundant in Manitoba and is becoming rather common in Ontario. It grows as an erect plant, with a number of branches from the upper part. The leaves are numerous during the first of the season, and clasp the stem by ear-line lobes. The flowers are white and small, with spreading flower stalks. The pods which succeed the flower are very characteristic. They are nearly orbicular, about half an inch broad, quite flat, with a broad wing all around, and notched at the top. Fig. 14 shows this peculiarity. Each pod produces about twelve seeds, which are dark brown to black and oval in shape, with curved lines. An average plant produces about 20,000 seeds.

The plant has a peculiar odour, resembling that of garlic, hence some of the common names. The seed also has a very pungent taste. When eaten by milch cows, it imparts a disagreeable flavor to the milk.

Time of flowering, May-September.

Time of seeding, June-September.

Dispersal—chiefly by the wind.

Eradication. Continuous growing of hoed crops with thorough cultivation thereof, followed by heavy seeding with rye. In places where the weed is very thick, mowing and burning is a good remedy. The method outlined for eradicating Mustard is applicable to this weed. (Fig. 15).



FIG. 14.
PENNY-CRESS.
(*Thlaspi arvense*.
[47]

FIG. 15.

WILD MUSTARD, CHARLOCK, OR HERRICK.

Brassica sinapistrum, (L).

Among the worst weeds in Ontario is the Wild Mustard, an annual, naturalised from Europe, with fibrous roots and erect habit of growth. The stem is rough, with stiff hairs somewhat scattered over the surface. The branches arise from the upper part of the stem and bear oblong leaves; and the lower leaves have one terminal large lobe and several smaller lateral ones (lyre shaped). The flowers are yellow, showy, and about $\frac{2}{3}$ in. broad, with stout flower stalks, which are more noticeable when the plant is in fruit. The pods, which appear on the lower part of the stem whilst the top is still in flower, are from 1 to 2 inches long, and are either spreading or ascending.

The shape of the pod is characteristic; it is constricted between the seeds, thus giving the appearance of a rounded enlargement where each seed is borne. This appearance is termed "knotted." The pod terminates in a two edged beak, and the two valves of the pod are strongly veined or ribbed.

The seed (See Fig. 15) is black, $\frac{1}{8}$ in. in diameter, perfectly spherical, and very much like rape or turnip seed; and it retains its vitality for a long time when buried in the soil. An average plant produces 15,000 seeds.

Time of flowering, June-September.

Time of seeding, July-September.

Dispersal—by birds and implements, but chiefly as an impurity in seed.

Eradication. Owing to the great vitality of the seed, Mustard is a very hard weed to eradicate. The seeds, once in the ground, live for years and continue to germinate as they are brought near the surface. Hence it takes patience, a great deal of labor, and a long time to get rid of the weed, when it once gets possession of the land. When present only in small amounts, hand-pulling is the best method, provided the pulling is done before seeds have formed; and as persons pulling in a hurry cannot wait to examine for seed, it is best to put the weeds, as they are pulled, in bundles where they can be burned when dry.

When fields are overrun with the weed, it is best to proceed as follows: Harrow stubble-ground early after harvest, or gang-plow and harrow. As soon as the seeds have had time to sprout, cultivate thoroughly; repeat cultivation at intervals; and rib up with a double mould-board plow the last thing in the fall. Put in a hoed crop, either roots or corn, the following spring, and cultivate it thoroughly throughout the growing season. Cultivate and harrow well two or three times after roots or corn, having first run the plow along each row of corn roots to cut the roots and turn them up; and rib up before the frost. (If the plow is used after roots or corn, it is likely to bring



FIG. 15.
MUSTARD.
(*Brassica sinapistrum*.)

more seed to the surface). Sow a crop of grain the following spring and seed with clover. Pull weeds by hand out of the grain crop; take a crop or two of hay, or pasture; and break up the clover sod, treating it as outlined in the note to Mr. Rennie's method of cleaning land. (See page 15). When necessary at any stage in this method, use a grubber or subsoil plow to stir the soil to a greater depth than is reached by the surface cultivation.

Blue stone method. When mustard plants are sprayed with a 2 per cent. solution of blue stone (blue vitriol, or copper sulphate), which is made by dissolving one pound in 5 gallons of water, or 9 pounds in 45 gallons of water, they are killed. It is necessary that the plants be sprayed early, just when coming into bloom, and on a fine bright day, if the best results are to be obtained. A barrel (45 gallons) should spray an acre.

FIG. 16.

WORMSEED MUSTARD, OR TREACLE MUSTARD.

Erysimum cheiranthoides, (L.)

A native weed, which seems to be spreading rapidly through the Province. Many specimens have been sent here for examination during the past year.

An annual or winter annual with erect and branching stems from 8 in. to 2 ft. high. The foliage is bright green and abundant. The leaves are long, tapering at the base into a short petiole, and they are covered with T-shaped hairs. The flowers are yellow and about $\frac{1}{4}$ in. across. The little stalks (pedicels) holding the pods, come out from the stem obliquely, but the pod stands erect on the pedicel, parallel with the stem. The pod is about an inch long and four-angled, with one row of seeds in each cell. The seeds are 1-16 in. long and light brown in color, with a furrow on one side (Fig. 16a). An average plant produces 25,000 seeds.

Seeds give a bitter taste to feed containing them.

Time of flowering June-July. Time of seeding, July-August.

Dispersal—frequently as an impurity in Clover seed.

Eradication. Hand-pulling and burning is the best remedy when the weed occurs in small quantities; but where there is much of it, the following procedure is advised: Harrow stubble-ground early after harvest, or gang-plow and harrow. As soon as the seeds have had time to sprout, cultivate; repeat the cultivation, and rib up the land with a double mouldboard plow the last thing in the fall. Put in a hoed crop, either roots or corn, the following spring, and cultivate thoroughly throughout the growing season. Cultivate after the roots or corn, sow a crop of grain, and seed with clover. If not too much, pull weeds by hand out of the grain crop; take a crop or two of hay or pasture; and break up the clover sod, treating it as outlined in note to Mr. Rennie's method of cleaning land. (See page 15.)



FIG 16.
WORMSEED MUSTARD.
(*Erysimum chieranthoides*)

FIG. 17.

SHEPHERD'S PURSE.

Capsella bursa-pastoris, (L).

A winter annual, naturalised from Europe, with a long, deep, tap root. The root leaves are lobed and form a large rosette which lies close to the ground, and in this state it passes the winter. The following spring a more or less branched stem arises, with arrow-shaped leaves thereon. The flowers are very small and white in color, and are much less conspicuous than the seed vessels, which are triangular in shape, and are attached to the stalk or pedicel at the lower apex of the triangle. From the character of these pods, the plant obtains its scientific and common name. The triangular pod is divided down the centre by a partition, forming two cells, each of which contains from 10 to 12 seeds, (Fig. 17, a). In size the plant varies greatly from a few inches to two feet, depending on the soil and locality. But even a very diminutive plant produces many seeds. The seed is very small, light brown in color, and oblong in shape, (Fig. 17). An average plant produces over 50,000 seeds. Fig. 17 shows shape of seed, also the arrangement of seeds in the pod.¹

Time of flowering, early spring till the beginning of winter.

Time of seeding, early spring till the beginning of winter.

Dispersal—as an impurity in grass seed; also by birds, as the pods when ripe open and drop the seeds, which are eaten by birds, and often evacuated without digestion or injury.

Eradication. It easily succumbs to cultivation; and as the plant spreads only by seed, persistent effort should be made to prevent seeding. The method employed against the preceding weed may be used for eradicating the Shepherd's Purse. (Fig. 16).

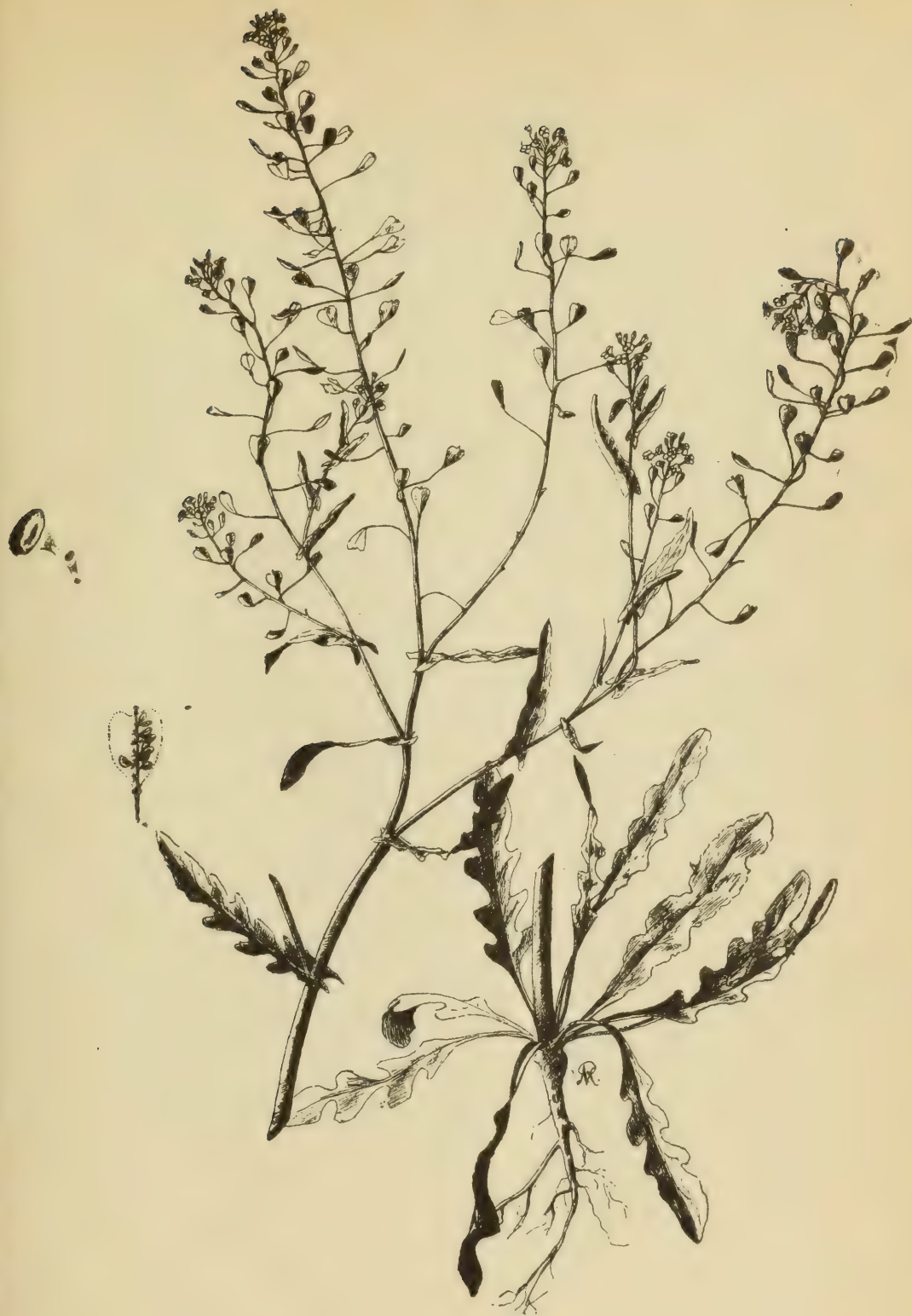


FIG. 17.
SHEPHERD'S PURSE.
(*Capsella bursa-pastoris*.)

FIG. 18.

FALSE FLAX, OR GOLD OF PLEASURE.

Camelina sativa (L).

This weed probably came to this country in imported flax seed. In Europe it is cultivated for the fine oil extracted from the seed, which is used in feeding cattle. Its common name arose from its supposed resemblance to flax.

An annual and winter annual, with simple or branching stems; the lower leaves are long, with a stem, or petiole; and the upper ones clasp the stem with arrow-shaped bases. The flowers are numerous, yellow, and somewhat inconspicuous. The seed vessel, or pod, is pear-shaped or globular, with a small projection from the upper end. The little stalks holding the pods are slender and spreading or ascending. The seed is brown and somewhat larger than that of Shepherd's Purse. (Fig. 18). An average plant produces about 40,000 seeds.

Time of flowering, June-August.

Time of seeding, July-August.

Dispersal—as an impurity in flax and clover seed, and occasionally in grain.

Eradication. Plow lightly as soon as the crop is harvested. Harrow and then cultivate frequently throughout the autumn, to destroy the young seedlings. It is important that this autumn cultivation should be thorough. Grow a hoed crop the following year. The rotation of crops should be modified in the infested fields by dropping winter wheat out for a time. Grass seed should be sown along with the spring wheat or barley.

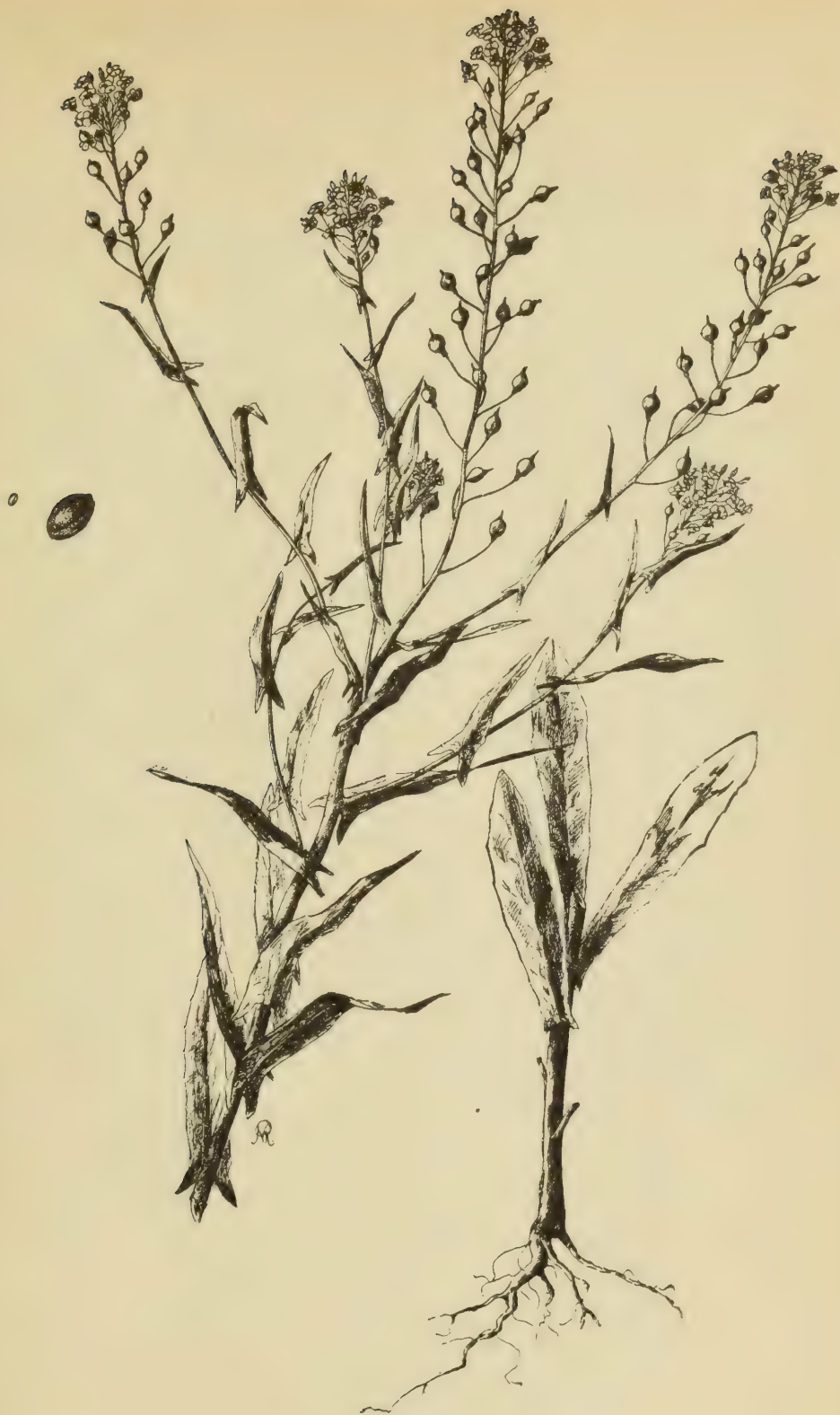


FIG. 18.
FALSE FLAX.
(*Camelina sativa*.)

FIG 19.

WILD CARROT, BIRD'S NEST, OR DEVIL'S PLAGUE.

Daucus carota (L.)

This is a biennial, naturalized from Europe, with a deep, strong tap root, a bristly stem, and much divided leaves like the cultivated carrot. The clusters of flowers are in compound umbels which resemble bird-nest cavities.

Time of flowering, July-September.

Time of seeding, August-December.

Dispersal—by seeds carried by wind and animals.

Eradication. Spudding is quite effective when the roots are cut before blossoming the first season. When the field becomes badly infested it should be plowed and cultivated and treated to a hoed crop, as described for the treatment of Blue weed (page 64).

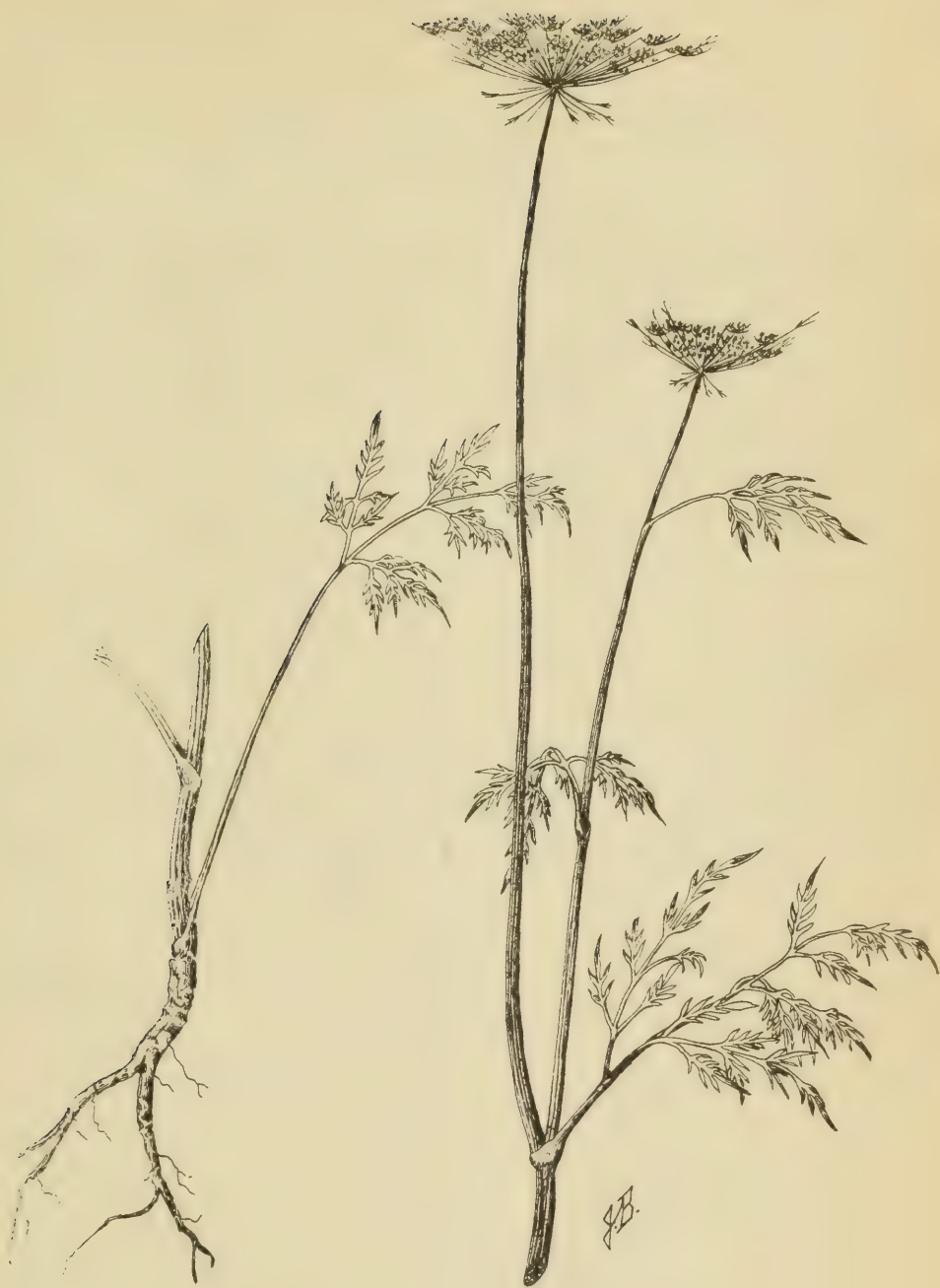


FIG. 19.
WILD CARROT.
(*Daucus Carota*. L.)

FIG. 20.

BINDWEED,

Convolvulus arvensis (L).

A very troublesome weed which winds its tough and curling stems around the stalks of various plants, partially chokes them, and thereby hinders their growth. It is a perennial with a very extensive creeping root which penetrates far into the soil, and any piece of the root possessing one or more buds is capable of starting new plants, hence it is necessary to clean implements very thoroughly after they have been used in a field containing this weed. The stems are branched and either trail on the ground or climb by twisting around some other plant. The leaves are rather small, with 2-4 lobes at the base, giving them an arrow-headed shape. The flowers are white or rose-colored and 1 inch across. The seeds, three in number, are large, black, and angular, and are held in a spherical capsule (Fig. 20). An average plant produces about 160 seeds.

Time of flowering, June-September. Time of seeding, August-October.

Dispersal—chiefly by means of its creeping roots; sometimes as an impurity in seed grain.

Eradication. This is a very difficult weed to eradicate, and careless cultivation only increases the trouble by carrying the roots from place to place. Salting is recommended by some practical farmers who have succeeded in eradicating this very troublesome pest; but we cannot speak from experience as to the value of this method of treatment.

The weed may be kept in check by the frequent introduction of well cared-for hoed crops into the rotation, and the shorter the rotation the better. The later sown hoed crops, especially rape, are more effectual than those sown earlier in the season. Before the hoed crop is sown, the weed may be kept in check by going frequently over the field with a broad-share cultivator, so as to cut all the plants an inch or two below the surface without bringing up any of the creeping root-stocks. About the 1st July the land may be sown with rape in drills, say 26 inches apart, and during the early growth of the crop the weeds may be kept in check by means of the horse-hoe, with more or less hand-hoeing. If the land has been well manured or is naturally rich in vegetable matter, the rape will make a rank growth and smother some of the weeds. The rape may be pastured in the fall, and in extreme cases may be followed by another hoed crop, such as corn. If the corn is well cultivated and hoed, most, perhaps all, of the plants will be destroyed.

In some cases it may be advisable to summer-fallow, and in such cases it is best not to plow more than is absolutely necessary, but to



FIG. 20.
BINDWEED.
(*Convolvulus arvensis*.)

depend mainly on the broad-share cultivator. Buckwheat sown on summer-fallow and plowed under when coming into blossom, followed by surface cultivation with broad-share cultivator, will assist very much in killing the weed. If necessary, the summer-fallow may be followed by a hoed crop.

FIG. 21.

DODDER, CLOVER DODDER, DEVIL'S GUT, OR STRANGLE WEED.

Cuscuta epithymum (Murr).

Judging from the number of enquiries made about Dodder, we fear that it is spreading rapidly in the Province of Ontario.

The seed takes root in the soil and puts forth a shoot which winds around some living plant. Having a good start, the shoot disconnects itself from the earth and derives its nourishment from the juices of the plant to which it clings. Drummond says:—"There are certain plants—the Dodder for instance—which begin life with the best intentions, strike true roots into the soil, and really appear as if they meant to be independent for life. But after supporting themselves for a brief period, they fix curious sucking discs into the stem (Fig. 21, (3)) and branches of adjacent plants, and, after a little experimenting, finally cease to do anything for their own support, thenceforth drawing all their supplies ready made from the sap of their host. In this parasitic state the Dodder has no need for organs of nutrition of its own, and Nature therefore takes them away. Henceforth, to the botanist, it presents the degraded spectacle of a plant without a root, without a twig, without a leaf, and having a stem so useless as to be inadequate to bear its own weight."

The stems are very slender and red in color, curling around clover or grass and completely choking it, as well as appropriating its juices. It puts forth dense clusters of small whitish flowers, which are succeeded by rounded pods full of seeds. The seeds are small, grey or yellowish-brown, and round in shape. An average plant produces about 2,500 seeds. There are numerous species of dodder, parasitic on flax, onions, and a variety of other herbs and small shrubs.

Time of flowering, June-July.

Time of seeding, July-September.

Dispersal—often as an impurity in clover and lucerne seed.

Eradication. Guard carefully against it in clover and other seeds. Cut before ripening, as near the ground as possible, collect, and burn; and modify the rotation so as to leave clover out for a time.

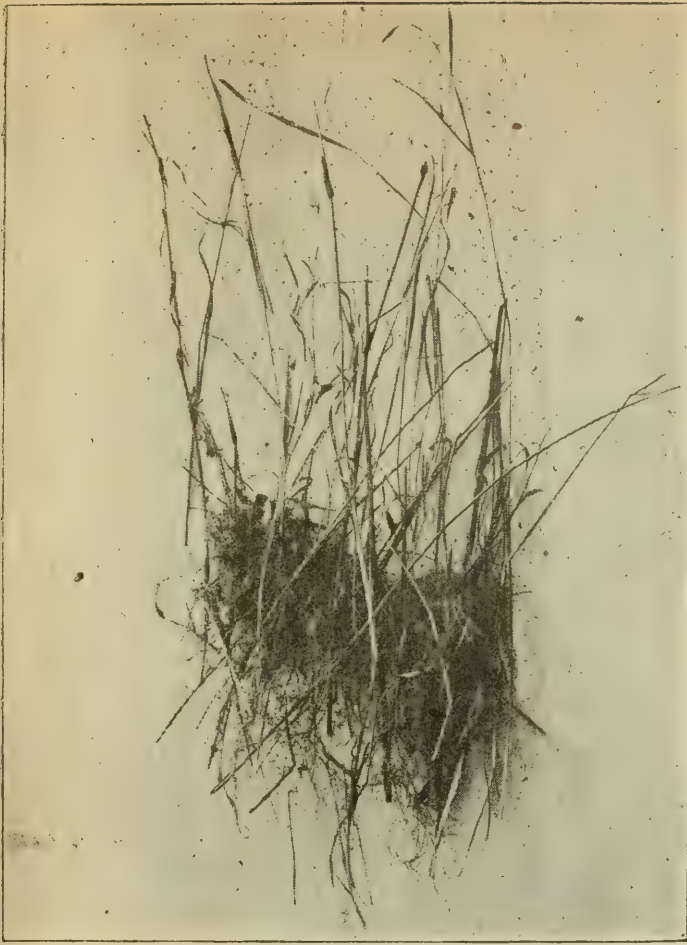


Fig. 21 [1]. DODDER ON GRASS AND CLOVER.



Fig. 21 [4].
DODDER SEED.
Natural size and enlarged five times.

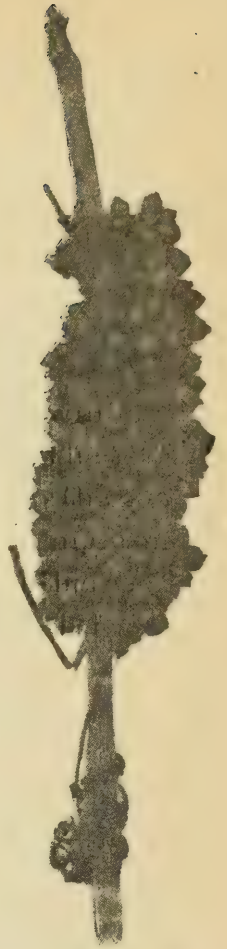


Fig. 21. [5]. DODDER.
Showing the seeds in situ.

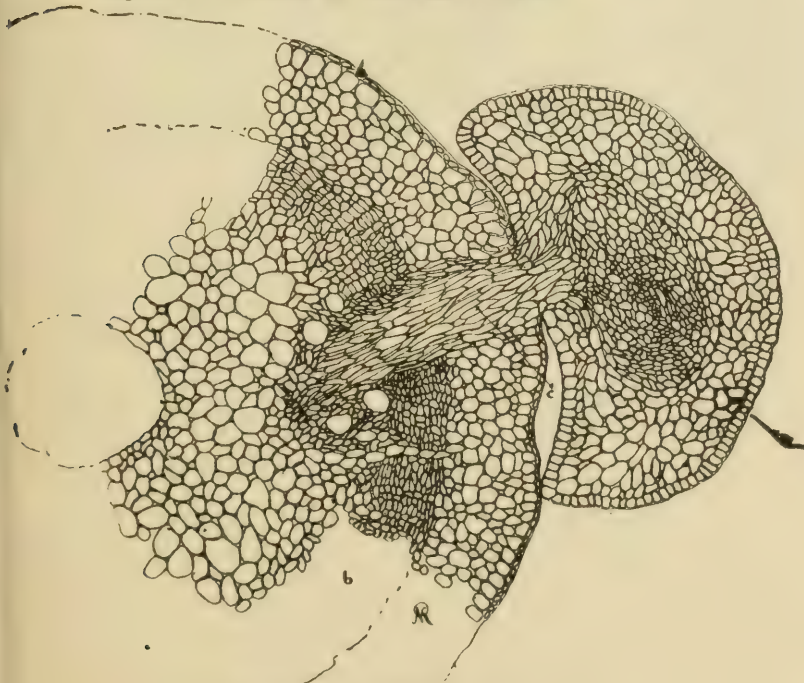


Fig. 21 [3]. DODDER.
(a) Cross-section of Dodder stem.
(b) Cross-section of Clover stem.
(c) Sucker from stem of Dodder.



Fig. 21 [2]. DODDER
growing on stem of Hop.
(After Kerner.)

FIG 22.

HOUND'S TONGUE, DOG BUR, OR BURS.

Cynoglossum officinale, (L.)

A biennial weed, with erect hairy stem, of rank growth, and much branched, one to three feet high. The lower leaves have petioles; the upper ones clasp the stem. They are 6-12 inches long and covered with downy hair, and have a disagreeable odour resembling that of mice. The flowers are small and lurid purple-red in color. The fruit consists of a broad, rounded bur, $\frac{1}{4}$ -inch long, with one flat side and covered with short spines which enable it to adhere to clothing or to animals (Fig. 22a). An average plant produces about 600 seeds.

Time of flowering, June-August.

Time of seeding, July-September.

Dispersal—chiefly by animals carrying the burs.

Eradication. Spud or cut deep in fall and early spring; the former to destroy the plant in its first year, and the latter to complete the destruction by removing those that escape the first cutting.



FIG. 22.
HOUND'S TONGUE.
(*Cynoglossum officinale*.)

FIG. 23.

BLUE WEED, VIPER'S BUGLOSS, BLUE THISTLE, OR BLUE DEVIL.

Echium vulgare, (L).

A biennial weed naturalized from Europe, with deep tap root, which penetrates to a great depth. During the first year, the portion above ground is a rosette of leaves; and from the centre of this, next season, bristly, hairy, and erect stems arise one to two and a half feet high. The leaves are oblong, two to six inches in length, with both upper and lower surface hairy. The flowers are numerous, arranged in a rich spire, and are azure blue in color. The seeds are hard and brown in color, with a broad base and angular body $\frac{1}{8}$ in. long (Fig. 23a). An average plant produces 3,500 seeds. The seeds are probably dispersed in winter by the wind, as they remain for a long time the plant.

Its names, both Latin and English, are significant of the notion that it was an effectual remedy against the bite of a viper.

The weed prefers gravelly and lime soils.

Time of flowering, July-October.

Time of seeding, August-October.

Dispersal—by seeds, especially in winter when they are blown over the snow.

Eradication. This weed gives very little trouble in arable land, if the cultivation is at all thorough. In fence corners, on roadsides, and in waste places, cutting below the crown with a spud, is practically the only effective method of destroying the weed. Sometimes, however, this is impracticable, because of the number; and in such cases, some special treatment, similar to that recommended for the Dock (Fig. 5) may be resorted to.



FIG 23.
BLUE WEED.
(*Echium Vulgare.*)

FIG. 24.

MULLEIN, OR VELVET DOCK.

Verbascum thapsus, (L).

The mullein is a weed introduced from Europe,—very common in waste places, road sides, and gravelly or sandy pastures. It is a biennial, with large, long roots, from which spring a tall and usually unbranched stem, 2 to 6 feet high. Both stem and leaves are densely woolly all over, with branched hairs. The leaves are whitish, thick, and velvety to the touch. The flowers are yellow and arranged on densely crowded elongated spikes. The capsule containing the seeds is about $\frac{3}{8}$ in. long, and the seeds are small, about 1-20 in. long, six-sided, with irregular ridges running lengthwise between the sides. The color of the seed is dark brown. An average plant produces 6,000 seeds.

Time of flowering, July-September.

Time of seeding, August-November.

Dispersal—as an impurity in clover and grass seed.

Eradication. Spud or cut below the crown; or dig up the roots when young; or break up the sod and grow hoed crops. It easily succumbs to cultivation.

The Moth Mullein (*Verbascum blattaria*), is a worse weed than the common mullein, as it infests meadows and bears far more seed. The seed is often found as an impurity in clover and timothy. The plant itself is smooth and slender, from 2-6 feet high, with dentate leaves. The flower is yellow, with brown marks on the back of the petals; and the stamens have violet filaments. The seed is brown, very small, and six-sided. Treat it the same as common mullein.

In Fig. 24 are shown the seeds of the mulleins—the upper seed is the common mullein, the lower is the moth mullein.



FIG. 24.
MULLEIN.
(*Verbascum Thapsus*).

FIG. 25.

PLANTAIN, BLACK PLANTAIN, RIB-GRASS, OR RIB-WORT.

Plantago lanceolata, (L.)

This plant was once very generally believed to be a favorite food of cattle, yet the opinion of most agriculturists is against it. It is considered a bad weed, especially when it appears in lawns. Numerous inquirers ask what it is, and how to get rid of it. It is a perennial or biennial, with a short thick root-stock, of erect growth, or more generally, lying on the ground as a rosette of leaves. At the base of the leaves there are tufts of brown hair; and the leaves themselves are long, narrow and tapering, with prominent veins, or ribs running lengthwise; hence some of the popular names. The flower-stock is slender and channelled, is without leaves and terminates in a dense spike. The stamens project from the inconspicuous flowers, giving a whitish appearance to the whole head. The seeds are enclosed in small pods, each containing two seeds. The seeds are about 1-12 of an inch long, brown and shiny, with a groove on one side, in the centre of which there is a black spot. The opposite side is rounded, as are also the ends (Fig. 25, a). An average plant produces 1,200 seeds.

Time of flowering, June-September.

Time of seeding, July-September.

Closely allied to this plant is the Broad Leafed Plantain (*Plantago major*), which has broad oval leaves and very long tapering spikes.

The seeds of both of these weeds are very common in clover and grass seed; and persons buying these seeds or lawn mixtures, should examine closely and guard carefully against plantain seed.

Eradication. If the plants are not numerous, cut below the crown with a spud. If they are, use treatment outlined for Mustard (Fig. 15).



FIG. 25.
PLANTAIN.
(*Plantago lanceolata*.)

FIG. 26.

RAGWEED, HOGWEED, BITTERWEED, OR ROMAN WORMWEED.

Ambrosia artemisiæfolia, (L).

Ragweed is an annual. The stem is much branched and slightly hairy, from 1 to 3 feet high. The leaves are very finely divided, the lower surface being of a lighter color than the upper. The flower heads are very numerous, from 1 to 6 inches long, green, and inconspicuous. The flowers are yellow, 1-6 inch across, infertile in the terminal spikes, and fertile only at the base of the spikes. The seed is dark brown, with a sharp tip, around which are arranged 4 to 6 spines, 3-16 inches long. They have great vitality and remain in the soil a long time without injury. An average plant produces about 5,000 seeds. The seed has a bad taste and gives a peculiar odour to the milk of cows which eat it.

Time of flowering, July-September.

Time of seeding, August-November.

Dispersal—as an impurity in seed grain; and by wind and water, being borne long distances by freshets.

Eradication. For the eradication of this weed, special attention must be given to the fall cultivation of the soil, to prevent seeds from ripening. Gang-plow or cultivate, and harrow stubble ground immediately after harvest, and repeat cultivation at intervals until late in the fall; then plow or rib up, and follow with a hoed crop. Care should be taken with the hoed crops that no specimens of Ragweed go to seed. When in grass, go over with a mower in September or October, if any plants are likely to mature seed. Do not sow late maturing crops. Ragweed when eaten by cows causes *bitterness* in milk.



FIG. 26.
RAG WEED.
(*Ambrosia artemisiifolia*.)

FIG. 27.

YELLOW DAISY, CONE-FLOWER, BLACK-EYED SUSAN, OR NIGGERHEAD.

Rudbeckia hirta, (L).

A biennial and sometimes annual weed found in pastures and meadows. It grows about 1 to 3 feet high. The stems are sparingly branched and very bristly. The leaves are thick, hairy, oblong and tapering towards the point. The flower is about 1 in. across, with orange yellow rays or petals (10 to 20 in number) and dark purple brown discs almost spherical or cone-shaped. The seeds are dark brown, almost black, four angled, and about $\frac{1}{8}$ in. long, with no pappus, or tuft of hair (Fig. 27, a). An average plant produces about 2,000 seeds.

Time of flowering, June-August.

Time of seeding, July-September.

Dispersal—as an impurity in seed grain.

Eradication. It can generally be killed by mowing, but it is sometimes necessary to break up meadow or pasture land, as suggested in note to Mr. Rennie's method of cleaning land (see page 16), and follow with a hoed crop. If this is well cared for, it will destroy all Cone-flowers.



FIG. 27.
CONE FLOWER.
(*Rudbeckia hirta*.)

FIG. 28.

OXEYE DAISY, WHITE DAISY, WHITE WEED, OR POVERTY WEED.

Chrysanthemum leucanthemum, (L).

The Oxeye Daisy is a weed naturalized from Europe, and is very closely related to the Chrysanthemum or national flower of Japan. It is a perennial with short, thick rootstocks, possessed of much vitality. Very many stems spring from one root. It grows from 6 inches to 3 feet high. The leaves slightly clasp the stem, the lower ones, narrow, long, and toothed along the edges, the upper ones, small and without teeth. They are slightly aromatic, more perceptibly so if bruised. The flowers are 1 to 2 inches broad, on long stalks, with from 20 to 30 white rays and bright yellow disc. The seed is about 1-12 in. long and angled, with alternate white and black longitudinal ribs. It has a short point but no pappus (Fig. 28). An average plant produces 7,500 seeds.

Time of flowering, June-August.

Time of seeding, June-September.

Dispersal—chiefly in grass seeds and by birds.

Eradication. The Daisy is most troublesome in pastures, and can be got rid of only by breaking up the sod. It can be eradicated by the method outlined for Canada Thistle (Fig. 30); or by seeding down to clover and plow up after one crop has been cut and taken off. The clover should always be cut before the Oxeye Daisy has had a chance to mature seed.



FIG. 28.
OXEYE DAISY.
(*Chrysanthemum leucanthemum.*)

FIG. 29.

BURDOCK, GREAT BUR, CLOT-BUR, OR BEGGAR'S BUTTON.

Arctium lappa (L).

A biennial weed with tremendous roots, probably the largest of all weed roots. This root is uniform in size for a foot below the surface; further down it is much branched and has a great hold on the ground. The stem is much branched (from 4 to 9 feet high) and rough, with broad rounded leaves, the lower surface of a lighter green than the upper. The flower heads occur in clusters and are purple in color. The flower receptacle, or involucre, as it is called, is composed of hooked spines, which are very adhesive and do much injury to the wool of sheep. The seeds are brown, $\frac{3}{8}$ in. long and spotted with darker brown (Fig. 29).

Time of flowering, July-September.

Time of seeding, August-October.

Dispersal—chiefly by animals carrying the seed from place to place.

The plant when burnt yields a good quality of alkaline ash, equal to the best potash; and a decoction from the roots is said to be equal to the juice of Sarsaparilla as a blood purifier, etc.

Eradication. Cut below the crown with a spud and burn the tops.



FIG. 29.
BURDOCK.
(*Arctium lappa.*)

FIG. 30.

CANADA THISTLE, OR CREEPING THISTLE.

Carduus arvensis, (L. & ROBS).

This weed was originally introduced from Europe, and hence incorrectly named Canada Thistle. It is a hardy perennial, with numerous underground stems which bear a large number of shoots. (See Fig. 29, illustrating two of these shoots). It grows to a height of 1 to 3 feet. The leaves are narrow and long, deeply indented into very prickly, lobed segments. The leaf has a crimped appearance, and at the base slightly clasps the stem. The under surface of the leaf is woolly, the upper surface less so. It produces numerous heads containing flowers, which are $\frac{1}{2}$ to $\frac{3}{4}$ inches across and of a lilac-purple color. The flower is smaller than that of other thistles. The seed is grey, oblong, and about 1-8 in. long, with slight longitudinal markings. Attached to the top is a conspicuous tuft of long hairs (the pappus) (Fig. 30, a). The seed is carried long distances by the wind. An average plant produces 3,500 seeds.

Time of flowering, June-August.

Time of seeding, July-September.

Dispersal—chiefly by the wind.

Great care should be taken to prevent Canada Thistle from seeding.

Eradication. The Canada Thistle can be eradicated in several ways, if thorough work is done at the right time :

1st. By careful and persistent spudding, done in such a way as to prevent the plant from developing top above the ground.

2nd. By early after-harvest cultivation of stubble ground.

3rd. By the frequent introduction of hoed crops into the rotation.

4th. By seeding much with clover, taking one or two crops of hay, plowing the clover sod shallow early after harvest, and cultivating frequently throughout the fall.

5th. By summer-fallowing.

Assuming that all land should be plowed in the fall, we may outline briefly one or two methods of destroying thistles :

(1) *In stubble ground for spring crop.* Gang-plow shallow and harrow early after harvest (immediately after the crop is off); and as soon as seeds have had time to sprout or thistles begin to appear, cultivate thoroughly with a broad-share cultivator, the points or shares overlapping far enough to cut all plants; and harrow again, to pull up and expose the plants that have been cut. Repeat the cultivation at intervals throughout the fall, and plow in the usual way, or, if possible, rib up with a double mould-board plow just before the frost. This systematic cultivation from harvest till winter, will check thistles and other weeds very much, and when followed by a hoed crop (mangels, corn, turnips, carrots, beans or rape), properly cultivated, it will not only clean the land, but put it into good shape for a crop of grain (oats, barley, etc.) the next spring, which crop should be seeded with red clover.



FIG. 30.
CANADA THISTLE.
(*Carduus arvensis*.)

(2) *In sod (meadow or pasture) for spring crop.* After one or two, but not more than two, crops of hay or pasture, plow shallow (not more than four inches) early after harvest, say the 1st to the 15th of August, and harrow at once. Let it stand a couple of weeks, and then cultivate the same way it was plowed, two or three inches deep, with a spring-tooth cultivator. After a while cross-cultivate a little deeper. If possible, cultivate a third, or even a fourth time, going a little deeper each time. Then, if you can manage to do so, rib it up with a double mould-board plow the last thing in the fall. This will make a good foundation for any crop the following spring—grain, roots, corn or rape—and if the portion in hoed crop is thoroughly cultivated with horse and hand hoes, very few, if any, thistles will be left. The portion intended for rape must be kept clean by surface cultivation till the time for putting in the crop, say the last half of June or the 1st of July, after which it should be treated like other hoed crops.

Some recommend a crop of fall rye on land which is intended for rape the following summer, but the rye takes so much moisture from the soil in the spring that the rape after it is apt to be a poor crop, unless in favorable seasons.

If summer-fallowing is resorted to, it will be well not to plow any more than is necessary, but to rely on surface cultivation with the broad-share cultivator and the harrow, done in such a way as to cut the plants two or three inches below the surface, without bringing up any of the numerous rootstocks which run along a little lower down. It will also be well to keep the fallow covered part of the summer by growing some kind of green crop, say a crop of buckwheat, sowed rather thick and plowed under when coming into bloom. This will help to prevent the loss of nitrates which bare land suffers from washing, and will improve the soil by increasing the supply of vegetable matter in it.

When necessary at any stage in the above method of cultivating either stubble-ground or sod, say for mangels, use a grubber or sub-soil plow to stir the soil to a greater depth than is reached by the surface cultivation.

FIG. 31.

CHICORY, OR WILD SUCCORY.

Cichorium intybus, (L).

A perennial weed introduced from Europe, with long, deep tap-root, which, when dried and ground up, is used in adulterating coffee and as a substitute for it. The stems are almost leafless, from 1 to 3 feet high, much branched, slightly hairy and whitish in color. The leaves, spread out on the ground, are long, with irregular edges. The flower heads are numerous, occurring in clusters, without flower stalks, on the naked branches. The flowers are about $1\frac{1}{2}$ inches across, bright blue in color, and are usually closed by noon. The seed is about 1-8

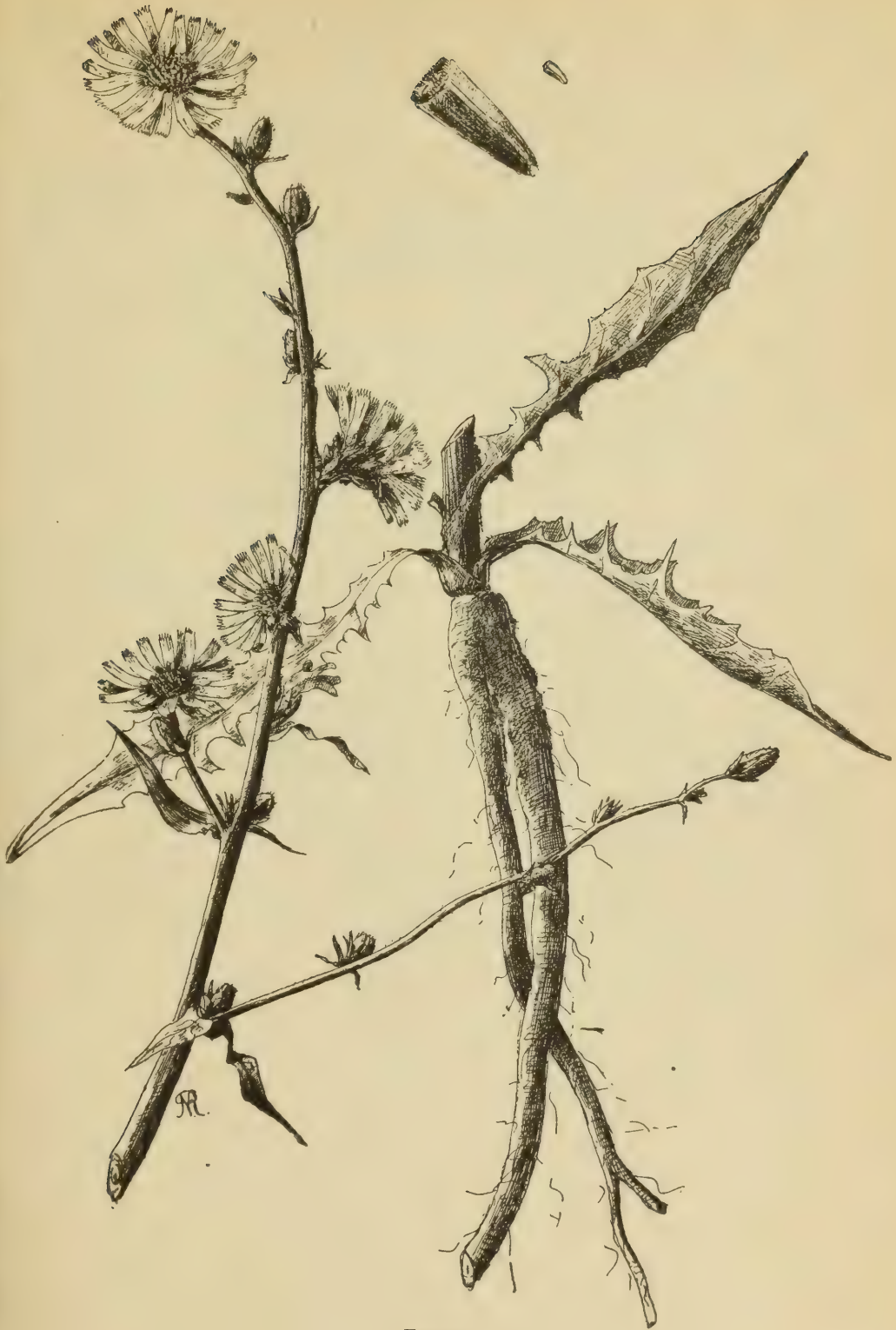


FIG. 31.
CHICORY.
(*Cichorium intybus*.)

in. long, tapering to a blunt point, the opposite end having a fringe of minute hairs around the crown. The body of the seed is corrugated. An average plant produces about 3,000 seeds.

Time of flowering, July-October.

Time of seeding, August-October.

Dispersal—frequently as an impurity in clover and grass seed.

Eradication. The method outlined for Canada Thistle may be followed in eradicating this weed, but the plow may have to be used more frequently than is advisable in combatting thistles.

FIG 32.

WILD LETTUCE, SOUTHERN THISTLE, OR TRUMPET-MILKWEED. (Erroneously called Prickly Lettuce.)

Lactuca Canadensis, (L).

An annual or biennial plant with a leafy stem, which may attain a height of seven feet. The leaves are deeply lobed, terminating in an acute point, and have stalks or petioles, the lower ones being smaller than those near the top of the stem. The stem branches at its summit into a compound flower-cluster. The flowers are small, yellow in color, and open only a few at a time. The seed is dark brown in color, flat and oval, with longitudinal ribs and a thread-like stalk at the apex, and possesses a small white tuft of hair (Fig. 32a).

Time of flowering, June-October.

Time of seeding, July-October.

Dispersal—chiefly by the wind.

Eradication. Where there is not much of it, pull and burn before ripening. Where this cannot be done, use the same method as for Mustard (Fig. 15).



FIG 32.
WILD LETTUCE.
(*Lactuca Canadensis.*)
[83]

FIG. 33.

PRICKLY LETTUCE.

Lactuca Scariola, (L).

Prickly Lettuce is a native of the old world, and has invaded this Province both from New York and Michigan. It is a winter annual; it springs from seeds in the fall, and survives the winter. The plant grows to a height of $3\frac{1}{2}$ feet; the stem is leafy and usually smooth; the leaves are oblong, and slightly pointed, often clasping at the base; the under surface of the midrib of the leaf is *spiny*: Heads are numerous and yellow.

Time of flowering, July-September.

Time of seeding, August-October.

Dispersal—By means of its seeds, which are provided with a pappus or tuft. An ordinary plant may produce 8,000 seeds.

Eradication. The best methods of destroying the weeds are: 1. To mow repeatedly as it comes into bloom, or earlier; 2. To cultivate thoroughly with a hoed crop. By this method the weeds in the soil will be induced to germinate. They should not be covered deeply in plowing. Mature plants should be cut down and burned lest the seeds be blown about and scattered by the wind.

Farmers should be careful to buy only clean clover, millet and grass seeds, and the weed inspector should insist on the fulfilment of the law, and have all fence-corners, roadsides, and waste lands cleared of the pest.



FIG. 33.
PRICKLY LETTUCE.
(*Lactuca scariola*.)

FIG. 34.

ORANGE HAWK WEED, DEVIL'S PAINT BRUSH.

Hieracium aurantiacum (L.)

A plant introduced from Europe, and a pernicious pest in pastures meadows and roadsides in the eastern portion of the Province. The heads are bright red orange in color, and are clustered. The stems grow to a height of 12 inches. The leaves are oval, downy, and greyish-green in color. The seeds are provided with tufts of down, whereby they are scattered by the wind.

Time of flowering, June to August.

Time of seeding, June to September.

Dispersal—This plant is propagated by roots, runners and tufted seeds: also by seeds purchased in clover seed.

Eradication. Salt at the rate of $1\frac{1}{2}$ tons per acre will kill this weed in pastures.



Fig
ORANGE HAWK WEED.
(*Hieracium aurantiacum* (L).)

FIG. 35.

ANNUAL SOW THISTLE, COMMON SOW THISTLE, OR MILK THISTLE.

Sonchus oleraceus, (L).

and *Sonchus Asper*, (Vill.)

AN annual weed introduced from Europe. It grows 2-3 feet high, has fibrous roots and leafy stem, and is not quite so large or coarse as the Perennial Sow Thistle. The leaves are much lobed, and have short, soft spines. Each head is many-flowered; but the flowers are small, about $\frac{1}{2}$ in. across, and of a pale yellow color. The seeds are brown, thin, and about 1-8 in. long, with longitudinal markings, and attached to the top is a large tuft of fine hairs united at the base.

Time of flowering, June-August.

Time of seeding, July-August.

Dispersal—chiefly by the wind.

Eradication. Cultivate stubble-ground and sod early after harvest and throughout the fall as for Canada Thistle (See Fig. 30.) Follow with hoed crop, preferably corn or roots, and cultivate thoroughly throughout the growing season. Use the cultivator, instead of the plow, after roots or corn; sow a crop of grain and seed with clover; if practicable, pull the weeds by hand out of the grain crop; take one or two crops of hay or pasture, and again break up the sod, plowing, harrowing and cultivating as for Thistle (Fig. 30).



FIG. 35.
ANNUAL SOW THISTLE.
(*Sonchus Asper.*)

FIG. 36.

PERENNIAL SOW THISTLE, FIELD SOW THISTLE, OR CORN SOW THISTLE.

Sonchus arvensis, (L).

A perennial weed, 1 to 3 feet high, with large and vigorous rootstocks, full of a milky white juice. The stems are rough, and the growth of the lower part of the plant is rank. The leaves are deeply cut and furnished with small spines, and at their base clasp the stem. The flowers are bright yellow, of fair size, $\frac{1}{2}$ in. across, and quite similar to those of the Dandelion. They close up in strong sunlight. The calyx, or flower cup, is green and covered with yellowish bristles. The seed is brown in color and about 1-8 in. long, with both longitudinal and transverse markings. To the top, a tuft of silken hair is attached (Fig. 36a.) An average plant produces about 2,000 seeds.

Time of flowering, June-August.

Time of seeding, June-August.

Dispersal—by running rootstocks, and the scattering of seeds by the wind.

The Sow Thistle draws much water from the soil and is a heavy feeder. It is less troublesome on stiff clays than elsewhere.

Eradication. The method used for the eradication of the Canada Thistle is recommended for this weed.



FIG. 36.
PERENNIAL SOW THISTLE.
(*Sonchus arvensis*.)

FIG. 37.

FLEABANE, OR HORSE WEED.

Erigeron Canadensis, (L.)

A tall hairy plant, very common in meadows. It is a winter annual. The stem is much branched and is hairy. The leaves are downy, from 1 to 4 inches long. The flower heads are numerous, about $\frac{1}{4}$ in. broad, with white flower rays. The seeds are small, light in color, and 1-16 in. long, with a pappus of short tufty hairs. An average plant produces 120,000 seeds (Kerner).

Time of flowering, June-September.

Time of seeding, June-September.

Dispersal—chiefly by the wind.

Eradication. Having a small root, this weed can be easily pulled. Hence, where there is not very much of it, hand-pulling is a satisfactory means of eradication. As a rule, the weed is troublesome only in meadows, and the frequent breaking up of meadow land tends to keep it under control.



FIG. 37.
FLEABANE.
(*Erigeron Canadensis.*)

NOTES CONCERNING OTHER NOXIOUS WEEDS.

Corn Spurry, (*Spergula arvensis*, L). This is an annual with small white flowers, and is related to the chickweeds. It grows from 7 to 12 inches in height. The needle-like leaves are in whorls at the joints of the stem, and the plant is covered with clammy hairs. It grows mainly on sandy soil. Its effect is to smother the crop. It seeds very profusely.

Treatment. Frequent stirring of the soil to make the seeds sprout, and frequent harrowing to destroy the seedlings.

Tumble Weed, or White Pigweed, (*Amarantus albus*). This plant resembles Russian Thistle quite closely, but can be distinguished from it by its round, shiny, jet-black seeds, and by its leaves, which, although small, have a definite blade. It is a low branched annual when growing in sandy, open fields and roadsides.

Treatment. Prevent the maturing of the seeds which ripen in August. The plants as a rule are conspicuous, and may be readily collected and burned. The seeds are often found in grass-seed mixtures.

Lady's Thumb, or Smartweed, (*Polygonum Persicaria*). This plant grows to a height of 12 to 18 inches. Its leaves are lance-shaped, usually with a blotch near the centre. It is an annual, and is often abundant.

Treatment. Prevent from seeding, and sow clean seeds.

Toad Flax, or Butter and Eggs, (*Linaria vulgaris*, L). This is a perennial which has escaped from cultivation as an ornamental, and become a decided pest. It grows in tufts, and has bright, yellow, spurred flowers. It flowers from July to October, and seeds from August to November. It propagates itself by root-stocks, and by seeds in grass seed. It is found chiefly in meadows and roadsides.

Treatment. Continuous cultivation will subdue it, but care must be taken not to spread the root-stocks. Coal-oil, salt, etc., are effective after hoeing.

Wild Barley, or Squirrel-Tail Grass, (*Hordeum jubatum*). This pest is a native of the western prairies, but is invading the western parts of the Province. It has a dense head, like that of barley, and grows to a height of 12 inches or more. It is quite a serious pest in Manitoulin Island and the districts farther west. It should be gathered and burned wherever found.

Wild Tares, or Perennial Vetch, (*Vicia cracca*, L.). This is a perennial plant, with a deep system of root-stocks. It is often reported difficult of eradication. The flowers are blue, and there are 10 to 12 pairs of leaflets to each compound leaf. This plant appears to persist most tenaciously in damp soil. The same cultivation which is used in controlling the Canada and Perennial Sow Thistles will subdue the Perennial Vetch.

The Cinque-Foils, or Five Fingers. There are two or three species of Cinque-Foils which are becoming quite noxious. The large-flowered Cinque-Foil (*Potentilla recta*) is a perennial, with cream-colored flowers. The Norway Cinque-Foil (*Potentilla Norvegica*) is also a pest in many pastures. Cultivation, spudding, and hoeing will keep these plants under control.

Pigeon Weed, Wheat Thief, Red Root, or Corn Gromwell (*Lithospermum arvense*, L.) A winter annual naturalized from Europe, with reddish roots. It is usually branched, and grows to a height of 12 inches. The leaves are sessile, narrow, and harsh to feel. The flowers are small and white; at maturity, four small smooth seeds are produced, which have considerable vitality.

Time of flowering from April to July.

Time of seeding from June to August.

Dispersal—mainly through seed grain, such as wheat, rye, timothy, and alsike clover,—often spread by birds, and distributed in the manure.

Eradication. Drop fall wheat from the rotation. Cultivate lightly after harvest and cause the seeds to germinate. When three or four inches high, harrow or plow them under. If this treatment is repeated each fall, wheat can again be grown.

Sweet Clover (*Melilotus alba*). The white sweet clover is a very common plant in vacant grounds and neglected fields about cities and along roadsides. It is a tall, rank growing plant, and thrives best on heavy clay soils. It may be classed among the weeds, inasmuch as it grows where it is not wanted, but it cannot be considered a noxious weed. As a soil-former sweet clover is a valuable plant. It roots deeply, and is a nitrate producer. With the aid of the rains and frosts it gradually mellows the soil of unproductive clay, and makes it fit for cultivation.

It is a biennial. The shoots of the first year's growth are tender, and are valued in the South as fodder for stock, but those of the second year are tough, fibrous, and branching, and bear the flowers which are very attractive to honey bees. In some districts sweet clover is grown extensively by apiculturists. The number of seeds produced every year by each plant is very large. Experience shows that sweet clover is not difficult to control. It grows altogether from the seed. If seeding is prevented by cutting down the plants at blossoming time very few plants will make their appearance the following season.

Although a fodder plant in the South, sweet clover is not relished by stock in Ontario. On account of the tough, fibrous structure of the second year's growth there is a possibility that the plant may in a few years be grown for the manufacture of binder-twine, etc.

INDEX.

	PAGE.		PAGE.
Bindweed, Field	58	Mustard, Wild	48
Burdock	76	Mustard, Wormseed	50
Blueweed	64	Mullein	66
Barley, Wild	91		
Canada Thistle	78	Ox-Eye Daisy	74
Chess	22		
Catchfly, Night-flowering	8	Pepper Grass	44
Campion, Bladder	40	Pigweed	34
Charlock	48	Pigeon Weed	95
Chicory	80	Plantain	68
Clover, Sweet	95	Penny Cress	46
Cockle, Corn, or Purple	38	Purslane	36
Cinque-foil	95		
Cockle, White	42	Quack Grass	26
Corn Gromwell	95		
Couch Grass	26	Ragweed	70
Cow Bell	40	Red Root	34
Cone-flower	72	Rib-Grass	68
Carrot, Wild	56		
		Smartweed	94
Dandelion	12	Squirrel Tail Grass	94
Daisy, Ox-eye	74	Shepherd's Purse	52
Daisy, Yellow	72	Spurry	94
Dock, Sour	28	Sorrel, Sheep	30
Dodder	60	Sow Thistle, Perennial	90
False flax	54	Sow Thistle, Annual	88
Foxtail	20	Sweet Clover	95
Fleabane	92		
Frenchweed	44	White Daisy	74
		Wild Oat	24
Hawkweed, Orange	86	Wild Tare	94
Hound's Tongue	62	Wild Carrot	56
		Wild Barley	94
Lamb's Quarters	32	Wild Lettuce	82
Lettuce, Wild	82		
Lettuce, Prickly	34	Yellow Daisy	72
		Yellow Dock	28

Ontario Agricultural College and Experimental Farm.

BACON PRODUCTION.

By G. E. Day, Professor of Agriculture and Farm Superintendent.

PART I.—BUILDINGS.

The question of buildings for swine is such a complicated one that it seems a hopeless task to attempt a discussion of the subject. Almost every piggery that is built possesses certain features peculiar to itself, and rendered necessary by the circumstances which it is intended to meet. All that will be attempted here, therefore, is a brief discussion of the desirable features of a piggery, illustrated by drawings of a cheap and convenient building which may be modified to meet almost any requirements.

The most important requirements of a piggery are dryness, ventilation, light, freedom from draughts, reasonable warmth, and convenience.

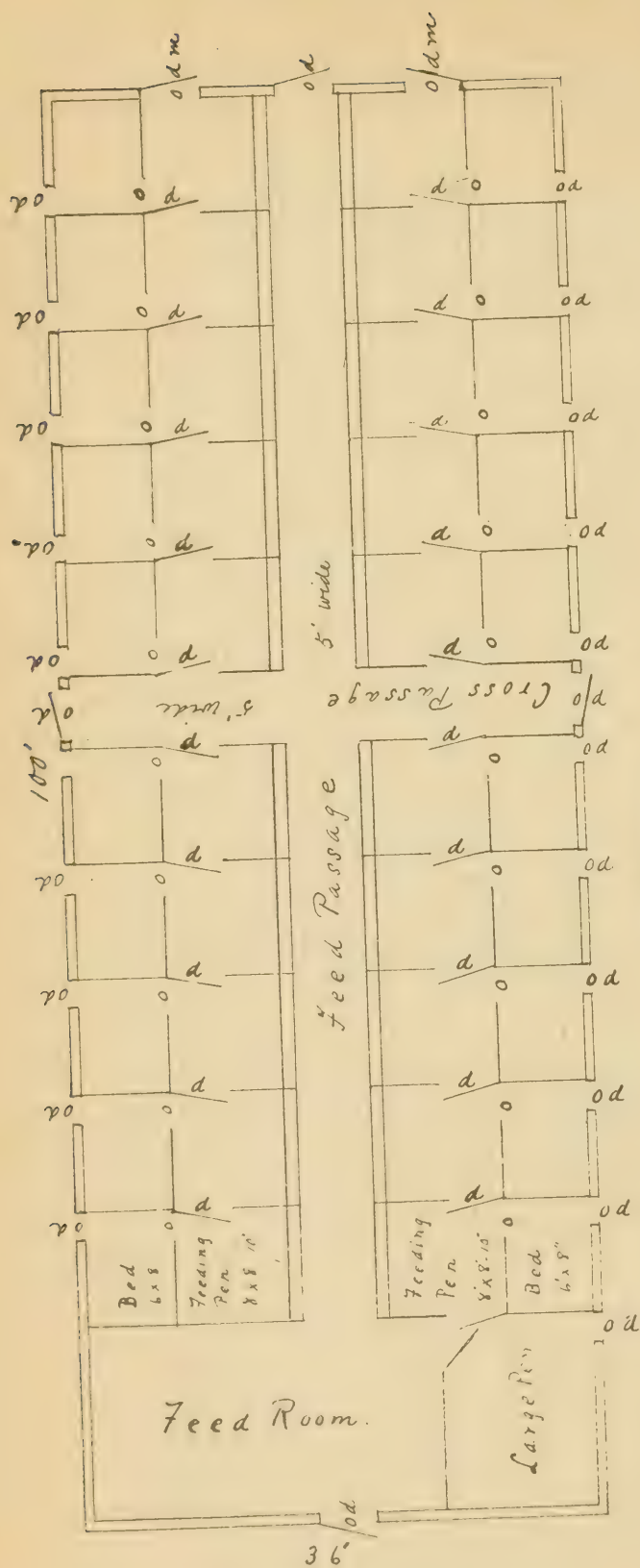
Dryness. Dryness is closely associated with ventilation, but is also influenced by the material of which the building is constructed. Good results can not be obtained in a damp pen; and dripping walls are a pretty sure indication of impending disaster. Rheumatism and numerous forms of unthriftiness result from dampness. Stone and cement walls are very cold in winter, and chill the air of the pen, causing it to deposit its moisture upon their surface. In a short time the wall becomes quite wet, and trouble is stored up for the pigs. A hollow cement wall is much less objectionable than a solid one; but our experience leads us to prefer wooden walls, constructed in such a way as to form a complete dead air space in the centre.

Ventilation. Thorough ventilation is a great help in preserving dryness; but it is a difficult thing to secure in a piggery without unduly lowering the temperature. It is a great aid to ventilation to provide a large air space, or, in other words, to have a high ceiling. The tendency at present is to do away with the common loft over the piggery, and to have the space above the pigs extend to the roof. This gives more air space, and makes ventilation a simpler problem. The admission of fresh air can be provided for by constructing shafts in the walls at intervals of fifteen or twenty feet. These shafts open outside near the ground, and inside, at the ceiling. Provision should be made for the closing, or partial closing, of these intakes when cold air is admitted too rapidly. Windows in the roof, as described in the plan, are a very effective means of removing foul air.

Light. Light, especially sunlight, has a wonderful influence in promoting health. So far as possible, the windows should be on the south side of the building, as the south side gets most sun, and is least exposed to cold winds.

Draughts. While ventilation is necessary, draughts are extremely injurious, and their prevention should be kept in view when building.

Warmth. Warmth is a good thing; but it should not be secured at the expense of ventilation. A somewhat cold pen, well ventilated but free from draughts, is preferable to a warm pen where the air is damp and foul, and the pigs will suffer less discomfort in the former than in the latter.



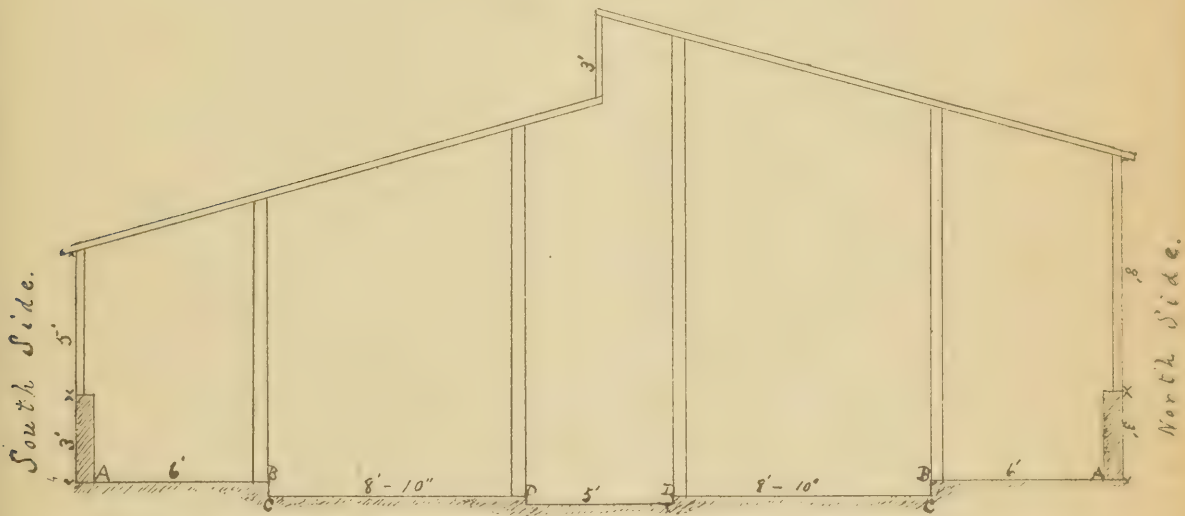
Plan of Piggery.

Explanations: o. Openings $2\frac{1}{2}$ feet wide between bed and feeding pen.
d. Doors 4 feet wide in partitions, which swing back and close openings at o.
o.d. Doors leading outside.
o.d.m. Doors for taking out manure, or taking in bedding.
Pens are uniform size throughout. Dimensions of pens include partitions.

PLAN OF PIGGERY.

The plan which is given here is taken from a new piggery built this year by Mr. J. E. Brethour, Burford, Ont. Its construction is comparatively cheap, and it possesses many desirable features. It is capable of many modifications; and a careful study of the plan will be helpful to those who intend to build. Of course, the building can be made any length desired.

The building is 36 x 100 feet, outside measurement. A cement wall 8 inches thick rises 3 feet above the floor. On top of this wall the frame is built. The walls are built of 2 x 4-inch studding, boarded on the outside with cheap lumber, covered with building paper and tightly clap-boarded on top of the paper. On the inside, the walls are lined with matched lumber, so as to form a dead air space inside. The lining also extends over the lower side of the rafters, giving a dead air space to the roof, as well as the walls.



Cross section of Piggery, showing contour of floor, shape of roof, and supports for same.

From the cross-section it will be seen that the total height of the wall on the north side is 11 feet and of that on the south side 8 feet. The roof has the same pitch on both sides, so that there is a drop of 3 feet from one section of the roof to the other, at the centre of the building. In this space windows are inserted to throw light and a certain amount of sunshine into the row of pens along the north side of the building. These windows are hinged at the bottom and can be opened at any angle according to the requirements of ventilation. A ratchet device, similar to that used for opening the ventilators in greenhouses, would be very convenient for this purpose.

The floor is cement. Cement is so durable and so easily cleared, that it seems to be about the only satisfactory floor. The part A B (see cross-section) is 6 inches higher than C D. There is a fall of $1\frac{1}{2}$ inches from A towards B, and a fall of 3 inches from D towards C. Thus all the drainage is towards C, the lowest point; and the bed, being on top of A B, is always dry.

There is a partition $3\frac{1}{2}$ feet high between the bed and the feeding pen, and the opening from the bed to the feeding pen is $2\frac{1}{2}$ feet wide. The partition shelters from draughts, and also economizes bedding by holding the straw in place. The other partitions are 4 feet high. The partition next to the feed passage is made of No. 9 coil steel wires, 2 inches apart at the bottom and grading to about 3 inches apart near the top. They are stiffened by a

heavy upright wire in front of each pen, fastened to the horizontal wires by means of washers used for that purpose. The wire partition is set in about $2\frac{1}{2}$ inches from the side of the trough next to the passage, thus allowing room to pour feed into the troughs.

The troughs are cement, and are 8 inches high next to the feed passage, 4 inches high next to the feeding pen, and 10 inches wide.

The feed passage, which is 5 feet wide, is 4 inches lower than the feeding pen. This is merely a device to show the pigs to better advantage.

The purpose of the doors in the partitions between the pens is easily understood. They can be swung back, closing the pigs in the back apartment and leaving a continuous passage for cleaning out the pens. The bedding is also taken in and distributed from this passage. These doors are also used in moving pigs from one pen to another, since there are no doors from the pens into the feed passage. The absence of doors from the pens into the feed passage is one of the most inconvenient features of the pen, but is hard to avoid where a wire partition is used. The wire partition, however, is more sanitary than wood and gives a much better view of the pigs.

It will be noticed that the sleeping quarters have cement floors. When bedding is plentiful this may give no trouble, but it would be a simple matter to place a portable wooden platform on the cement.

The roof is supported by the four lines of posts to which the partitions are fastened. Each row carries a line of plates which support the rafters.

There are six windows, each 5 feet long by $2\frac{1}{2}$ feet high, in the south wall, and the same number in the roof, placed as previously described. The north wall has only two windows.

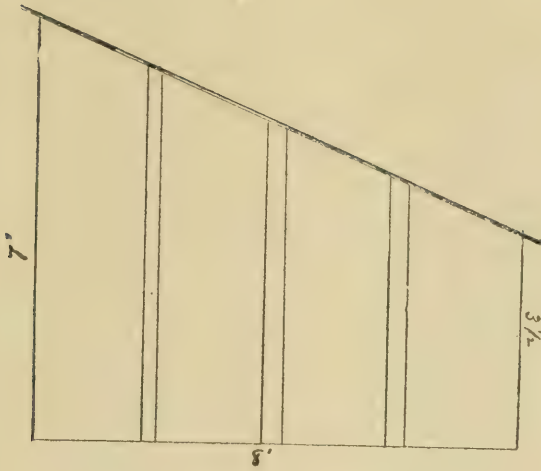
The dimensions given for the small pens, include partitions.

The pens as described are not suitable for farrowing pens. As a matter of fact, it is better to have sows farrow in a building away from other pigs, especially during cold weather when the building must be kept pretty well closed up. The air of a piggery where a large number of pigs are kept, does not seem to agree well with little pigs. However, if it were desired to have the sows farrow in the large piggery, one of the sections on the south side could be modified to answer the purpose by making the sleeping apartments $2\frac{1}{2}$ feet wider, thus giving beds $8 \times 8\frac{1}{2}$ feet.

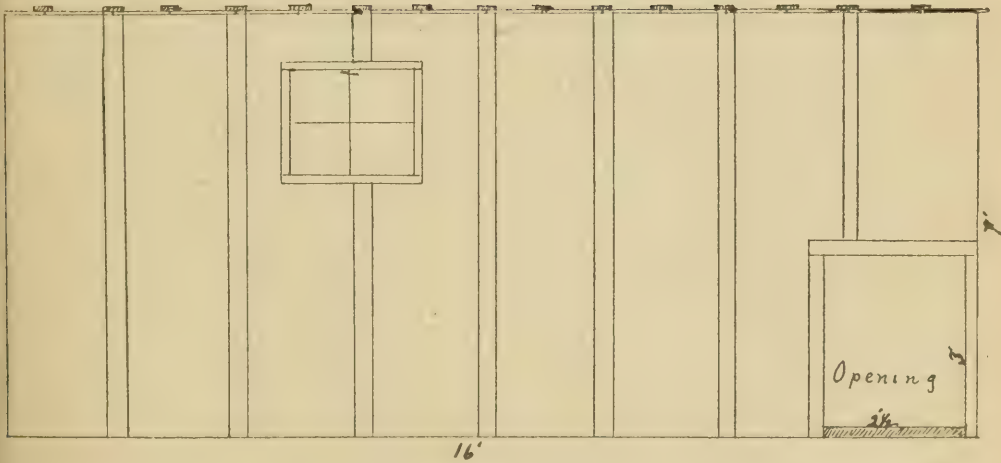
The absence of a loft for storing straw will be a strong objection in the eyes of many. The ventilation of the building, however, and the health of the animals are of vastly greater importance than the inconvenience occasioned by the absence of a loft. It is generally possible to locate the building so as to make it comparatively easy to obtain straw for bedding.

PORTABLE PENS.

The accompanying sketches show a very cheap and easily constructed pen, suitable for winter quarters for breeding sows. The pen is 16 feet long by 8 feet wide. It is 7 feet high in front and $3\frac{1}{2}$ feet high at the rear. It is boarded with cheap lumber, but all cracks are securely battened. It should be practically wind and rain proof. The opening is at one corner; and the pen should be set with the opening towards the south. A door is not necessary. Plenty of bedding should be supplied, and the pen should be banked outside with horse manure to the depth of about two feet. This method of housing sows is better than close confinement in warm pens. The same pens will answer for shelter from the sun in summer.



End view of Portable Pen.



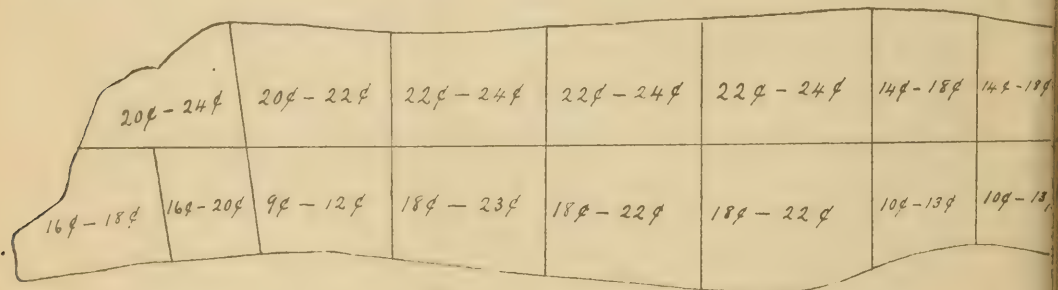
Front view of Portable Pen.

PART II.—THE CANADIAN EXPORT TRADE.

In the United States there is an immense home market for lard and oleomargarine (artificial butter). In Canada we have no trade in oleomargarine and a very much smaller home market for lard. The American packer, therefore, can utilize very fat hogs, manufacturing lard and oleomargarine from the fat and placing only the leaner carcasses and the lean parts of the fat carcasses upon the market to be consumed as meat. On the other hand, practically all the Canadian hogs must be consumed as meat; and as there is a very limited and decreasing demand for fat pork the production of a leaner class of hog has become a necessity in Canada. Great Britain is the home of the export trade in pork products of both Canada and the United States, the latter country exporting vastly larger quantities than Canada; and to keep out of a hopeless competition with the Americans our packers have been forced to cater to an entirely different class of customers. Thus it comes that the lean and carefully prepared bacon of Canada is taken by the large cities and retailers to the well-to-do classes, while the American product goes mainly to a less fastidious class of customers at a lower price. Canadian bacon, therefore, does not come into direct competition with the bulk of the American product in Great Britain; and a very little consideration of facts outlined above should convince any thoughtful person of the importance of avoiding American competition as far as possible. As a matter of fact, we are compelled to go on with the fat hog business, owing to the vast advantages possessed by the Americans in the way of markets for their products.

The kind of bacon of which Canadian packers make a specialty is what is known as the "Wiltshire side." Denmark and Ireland are our main competitors; but their conditions are somewhat similar to our own, and the competition, therefore, is not a hopeless one. At the same time, we need to put forth every effort if we are to hold our own in the British market; and hence we require to give the subject of bacon production most careful study.

To make Wiltshire sides, a hog is required weighing from 160 to 220 pounds live weight. These are not cast-iron limits, though 160 pounds is rather too light for making the best side. The most suitable weights are from 180 to 190 pounds. The diagram which follows shows a retail dealer's method of cutting a Wiltshire side and the approximate retail values in Great Britain.



A Wiltshire Side,

Showing retail dealer's method of cutting, and approximate range of retail values in Great Britain.

The diagram shows that the most valuable meat is found along the upper part of the side as far forward as the shoulder. When the shoulder and neck are reached there is a very material drop in the value. This teaches that a hog with a heavy, rough shoulder produces a very undesirable side, because it gives a side which is heavy at the cheap end. It teaches further that a hog should have good length from the back of the shoulder to the hind leg, because this is the most valuable part of the side of bacon. It will be noted



Fig. 1. No. 1 selection.



Fig. 2. Fat.

also that the belly meat is cheaper than the part above it, and this explains why we require the bacon hog to have a trim belly and a straight underline.

The figures given on page 7 are from photographs of sides from hogs used in our breed experiments.

Fig. 1 shows a No. 1 side. Note the uniformity in thickness of the layer of fat along the back. This layer of fat should be from $1\frac{1}{4}$ to $1\frac{1}{2}$ inches in thickness, and should be practically the same thickness from loin to neck. The side is very uniform in depth also, and does not show undue weight on shoulder and neck. Compare this with Fig. 2, which represents a fat side. There is too much fat all along the back, and the fat arches considerably over the shoulder. If these two sides are compared with the diagram, it will be seen at a glance how much more cheap meat is shown in Fig. 2 than in Fig. 1. The side shown in Fig. 2 came from a hog possessing a heavy, arching neck, a broad shoulder, broad, fat back, and a deep, heavy belly.

The conformation required for bacon production is described more fully under selection of boar and sow.

PART III.—BREEDING FOR BACON.

To produce the best type of hog for bacon production, care must be taken in the selection of breeding stock. There are those who claim that it is practically all a matter of feeding; but this is a very serious mistake. It is true that by careful feeding an objectionable type of hog can be greatly improved, but it can never be made to produce an ideal side of bacon. To produce the best bacon, both the breeding and the feeding must receive careful attention.

BREEDS OF SWINE.

In 1896 an experiment was commenced for the purpose of comparing six breeds of swine, both as regards economy of gain and suitability for the export trade. The breeds used were Berkshire, Yorkshire, Tamworth, Chester White, Poland China, and Duroc Jersey. The experiment was repeated in 1897, 1898, 1899, and 1900, making five carefully conducted tests. In each of the five years, six pigs of each breed were used for the test. In 1901 the same breeds were again fed under the same conditions, using a larger number of each breed. This experiment, however, was conducted for the purpose of comparing outside with inside feeding, and no attempt was made to compare the relative cost of production in the different breeds. The breeds were compared however as to suitability for export.

Altogether, therefore, we had five experiments in which the six breeds were compared as to cost of producing 100 pounds gain, live weight; and six experiments in which the six breeds were compared as to their suitability for export.

THE RELATION OF BREED TO ECONOMY OF PRODUCTION.

The table given below shows the average amount of meal required for 100 pounds gain, live weight, in the five experiments. In the making up of this table only the meal has been considered. Such foods as dairy by-products and green feed, which were fed sometimes, were the same for all breeds, and have been omitted to simplify the comparison.

The following shows the average amount of meal consumed for 100 pounds gain, live weight, in five experiments:

Pounds.		Pounds.	
Berkshire	364.45	Duroc Jersey	384.23
Yorkshire	369.51	Chester White	387.89
Tamworth	380.47	Poland China	391.42

Before any conclusions are drawn from the table given above, a second table will be presented for consideration in connection with it. This table shows the standing of the breeds for each year, each column being ranked in order of economy of gain:

Table showing the different breeds ranked in order of economy of gain for each year of the experiment:

1896.	1897.	1898.	1899.	1900.
Berkshire. Tamworth. Poland China. Duroc Jersey. Chester White. Yorkshire.	Berkshire. Tamworth. Poland China. Chester White. Yorkshire. Duroc Jersey.	Yorkshire. Berkshire. Duroc Jersey. Tamworth. Chester White. Poland China.	Berkshire. Tamworth. Yorkshire. Chester White. Duroc Jersey. Poland China.	Berkshire. Yorkshire. Duroc Jersey. Chester White. Tamworth. Poland China.

In considering these tables we must bear in mind that averages are frequently misleading. For example, in a certain experiment one breed may suffer from some unfavorable circumstance which is in no way related to, or influenced by the breeding of the animals; yet this circumstance may seriously affect the average standing of the breed in question.

A study of the last table reveals the fact that there is little or no constancy in the standing of any one breed, except the Berkshires, which certainly make a remarkably good showing. It may be possible that the Berkshires were able to digest and assimilate a larger percentage of their food than were the other breeds, but we believe that, at least, a large share of their success was due to another cause. All the pigs used in these experiments were purchased at ages varying from six to ten weeks, and it was noted that the Berkshires seemed to adapt themselves to the new conditions and change of food more readily than any of the other breeds, and thus scored an advantage at the commencement of the experiment, which they generally held until the close. We are inclined, therefore, to attribute their high standing to their ability to adapt themselves to changed conditions, rather than to their power to digest and assimilate a larger percentage of their food.

Everything considered, we are led to the belief that there is little, if any, relation between breed and power to digest and assimilate food, and that individuality is the all-important factor in this connection. To produce bacon cheaply we require a healthy, thrifty, growthy pig. Whether its color is red, white or black; or whether its ears are erect or drooped, are largely matters of taste.

RELATION OF BREED TO THE EXPORT TRADE.

It has already been stated that we had six experiments, in which six breeds of swine were compared as to their suitability for producing export bacon. In each experiment the hogs were shipped to the Wm. Davies Co., Toronto, where they were slaughtered and the carcasses critically examined by an expert, who was given no information as to the breeds which they represented. The table given below shows the different breeds ranked according to suitability for the production of "Wiltshire sides."

1896.	1897.	1898.
1. { Yorkshire. 2. { Tamworth. 3. Berkshire. 4. { Duroc Jersey. Poland China. Chester White.	1. Yorkshire. 2. Tamworth. 3. { Berkshire. Chester White. Duroc Jersey. Poland China.	1. { Yorkshire. Tamworth. 3. Berkshire. 4. Poland China. 5. { Chester White. Duroc Jersey.
1899.	1900.	1901.
1. Yorkshire. 2. Tamworth. 3. Berkshire. 4. { Chester White. Duroc Jersey. Poland China.	1. Yorkshire. 2. Berkshire. 3. Chester White. 4. Tamworth. 5. Duroc Jersey. 6. Poland China.	1. Yorkshire. 2. Tamworth. 3. Berkshire. 4. Duroc Jersey. 5. Poland China. 6. Chester White.

From this table it will be seen that the Yorkshires had a very distinct advantage in this part of the experiment. The Yorkshire carcasses were characterized by good length of side, uniformity in thickness of fat along the back, a good general development of flesh (lean), thickly fleshed loin, thick, fleshy belly, and a fleshy ham which required little trimming. Their most serious faults ran in the direction of an undue weight of shoulder, coarseness of bone and thickness of skin, though these defects were noticeable in only a small proportion of the carcasses.

The Tamworths generally had a light shoulder and a very uniform layer of fat along the back; but, as a rule, they did not quite equal the Yorkshire in length of side, thickness of loin and belly, and development of ham. In many of them there was a marked lack of flesh over the loin, accompanied by a thinness of belly and a decided lightness of ham.

The strong point of the Berkshire carcasses was their large muscular development, giving a fleshy carcass. The ham was well developed; but, in many cases, it carried too much fat and required considerable trimming. The main faults were the shortness of side and an undue weight of shoulder, with the fat running very thick over the shoulder top. There was, moreover, a marked lack of uniformity in the Berkshire carcasses, some of them making capital Wiltshire sides, while others were entirely unsuitable. The Yorkshire carcasses, on the other hand, were specially noted for their uniformity.

The Chester White, Poland China and Duroc Jersey carcasses were very similar in character. Occasionally a good Wiltshire side was found among them; but it was a noteworthy exception. Shortness of side, a superabundance of fat, and a lack of flesh were generally characteristic of the group.

RELATION BETWEEN BACON TYPE AND ECONOMY OF PRODUCTION.

The results of our experiments are in direct opposition to the theory that it costs more to produce a pound of gain in a hog of the bacon type, than in one of a thick, fat type. It is true that the Berkshire made a better showing in regard to economy of gain than the Yorkshires and Tamworths, which scored highest in the slaughter test; but it is also true that the Berkshires were much superior as bacon hogs to the Duroc Jerseys, Poland Chinas and Chester Whites, and stood higher in point of economy of gain. The last three breeds were the least suitable for export; and they also stood at the bottom of the list in point of economy of gain. If the tables given above prove nothing else, they certainly demonstrate very clearly that a hog of good bacon type can be fed just as cheaply as one of an undesirable type. This also applies to animals of the same breed, but of different types.

SELECTION OF THE BOAR.

It is perhaps unnecessary to say that the boar should be pure bred. The pure-bred male will transmit his own qualities to his progeny and produce pigs more uniform in character than will a grade or a cross-bred. Not only should he be pure-bred but he should be well-bred; that is to say, he should belong to a family noted for its general excellence in the qualities which we desire to reproduce. In addition to these things he should himself possess those qualities which we wish to see in his progeny. A boar of this description is likely to give satisfactory results.

BACON TYPE IN BOARS.

In the first place a boar should show male character and give indications of strong constitution. He should have good width between the fore legs and be thick through the heart, or just back of the elbow. He should be

deep from the top to bottom back of the shoulder; and the space back of the shoulder should be well filled out, giving a good heart girth. The jowl should be broad and strong, but not fat and flabby; the forehead broad, and the poll broad and full. The neck should be of medium length and strongly muscled, but should show no heavy crown of fat. The eye should be large, full and bright, and his general appearance should indicate alertness and activity.

The shoulders are heavier than would be desirable in a sow or barrow, and as he grows older "shields" develop on the sides, which often give the appearance of roughness. He should be very compact on top, however, and blend well with the top line and the rib at this point. The bacon type shoulder is upright, making the animal comparatively short from the back of the shoulder to the head, and long from the back of the shoulder to the ham. This formation gives the largest development where the meat is most valuable.

The spring of rib is very characteristic. It should arch out boldly from the backbone, then suddenly drop in an almost vertical direction, giving a flat, straight side. This point should receive special attention in making a selection, for it is a sure indication of a strong development of muscle along the back; and muscle is lean meat.

The top line should rise slightly above the straight line, giving a very slight arch, the highest point of which is over the loin. The back should be of medium width and uniform in width throughout. The loin should be as wide as the rest of the back and be full, strong and heavily muscled. The rump should be the same width as the back and loin, slightly rounded from side to side over the top, and from the hips to the tail. The ham should taper towards the hock and carry the flesh well down towards the hock, especially on the inside of the shank.

The underline should be trim and straight, showing no tendency towards a sagging belly; and the hind flanks should be full, giving good thickness through at this point.

The legs should be of medium length, and the bone heavy, but clean and presenting a flattish appearance. Rough, puffy legs are very undesirable; and it is also a serious objection to have the bone fine. The pasterns should be upright, so that the animal walks well up on his toes. A hog with weak pasterns should not be bred from.

The hair should be abundant, but not coarse. A row of bristles standing up along the neck and over the shoulder top is extremely objectionable.

The carriage should be easy, the animal walking without apparent exertion, and without a swaying movement.

SELECTION OF THE SOW.

For the production of bacon it is not absolutely essential that the sow be pure bred. A grade sow of good type will usually produce very good pigs for bacon purposes, provided the boar is such as has been described in regard to breeding and quality. Many feeders prefer a cross between two distinct breeds; and, no doubt, this method has produced many excellent pigs. What is the best cross will probably never be known, as it is largely a question of the individuality of the animals used. We have crossed the Yorkshire and Tamworth with the Berkshire and Chester White with very good results; and we have also crossed the Yorkshire with the Tamworth with very fair success. As yet, however, we have conducted no systematic experiments in cross-breeding.

A sow should be selected from a prolific mother, because fecundity is hereditary. The number and development of the teats should also be noted, and at least eleven fully developed teats should be insisted upon. The teats

should be set well apart, and the front teats should be well forward on the body.

Bacon Type in Sows. The sow is finer in head, neck, shoulder, and bone than the boar. Outside of these points, the description given of the boar will also apply to the sow. Extremes should be avoided. A long, scrawny neck, narrow chest, and long coarse legs, indicate a slow feeder and an undesirable quality of bacon. The carcase of such an animal contains too much bone, and is deficient in muscle, or lean meat. The thick, short type is also undesirable; and the best bacon type is a mean between two extremes. Though coarse bone is bad, it will not do to go to the other extreme and select very fine bone. The bone should be clean and strong; and there should be enough of it to insure a good-sized animal. Weak bone, which tends to break down at the pasterns, should not be tolerated.

PART IV.—FEEDING FOR BACON.

Soft Bacon. If we are to maintain and develop our trade in bacon with Great Britain, it is of the greatest importance that we pay strict attention to quality. Not only must our hogs be bred to give the desired conformation; but they must be fed and managed in such a way as to give the desired quality. One of the greatest defects in quality with which our packers have to contend, is a tendency of some sides to turn soft during the process of curing. Softness has nothing to do with fatness; in fact, a thin side is more apt to develop softness than a fat one. In a soft side, the fat is soft and spongy; and sometimes even the lean is affected. There are all degrees of softness up to a mere slight tenderness; but any degree of tenderness detracts very much from the value of a side; and a really soft side is practically worthless. The percentage of soft sides is sometimes very high, even as high as 40 per cent. of the total at certain seasons of the year. It will, therefore, be easily understood that such a condition represents an enormous shrinkage in value; and this loss is bound to be reflected in the prices paid the farmer for his hogs, to say nothing of the injury to the reputation of our bacon in Great Britain. This is not a matter, therefore, which affects merely the packer. It affects the bacon industry as a whole; and the farmer, sooner or later, must shoulder the loss. It is important, therefore, that the farmer should pay particular attention to the question of quality.

CAUSES OF SOFT BACON.

To describe all our experiments under this head would occupy too much space, and would be found tiresome, and perhaps confusing, to the average reader. The conclusions which follow are based upon a careful analysis of our work to date, descriptions of which have been published from year to year in the annual report of the college. We have also been able to draw upon considerable unpublished data.

Exclusive Meal Feeding. This is perhaps one of the most common causes of softness, especially when hogs are confined in pens from birth to the time of marketing. Some kinds of meal are more dangerous than others; but wherever exclusive meal feeding is practised, and the exercise is limited, more or less softness is almost sure to result.

Corn and Beans. Of the grains in common use, corn has the greatest tendency to cause softness. Its injurious tendency can be modified by mixing it largely with other meal, and by feeding skim milk, green foods, and roots; but its tendency to produce softness is so strong that it must be regarded as an undesirable food.

We have not experimented with beans; but the Central Experimental Farm at Ottawa found that beans have an effect similar to corn.

Lack of exercise. Lack of exercise has a tendency to produce softness; but this tendency can be largely overcome by judicious feeding.

Unthriftness. Unthrifty hogs, no matter what the cause may be, invariably produce soft bacon.

Lack of finish. Thin hogs have a marked tendency towards softness. Marketing hogs before they are properly finished, is no doubt responsible for a good deal of softness.

Holding back. When a hog is finished, it should be marketed at once in order to produce firm bacon. If the feed is cut down, so that the hog makes no gain in weight for some time, or loses in weight, the bacon from such a hog is almost sure to be soft.

PRODUCTION OF FIRM BACON.

From what has been said, it will be seen that softness may result from a number of causes; and it is possible that there are causes outside of those mentioned. Enough has been said, however, to place the feeder on his guard against the most common causes; and below are offered a few suggestions regarding methods of feeding, and management which we have found to give good results.

Feeding. As already stated, exclusive meal feeding is apt to injure the quality of bacon. We have also found that it does not give so economical gains as a mixed diet. Among the foods which we have used along with meal, are skim-milk, whey, roots, rape, vetches, and clover. We have found that these foods, combined with a liberal meal ration, invariably give better gains than an exclusively meal ration, and produce a better quality of bacon. It is probable that much of the beneficial influence of these foods is due to the fact that they help to keep the animals healthy and thrifty, a condition necessary to the production of the best quality of bacon.

But while these succulent foods have an important place in hog feeding, they may also be abused. If an attempt is made to feed hogs almost exclusively upon them, the chances are that the hogs will not be properly finished, and soft bacon will likely result. The use of various foods will be found more fully discussed under "Notes on Foodstuffs."

Exercise. In our experiments, we have found that unlimited exercise during the fattening period is not conducive to cheap production. At the same time, the exercise has a good effect upon the firmness of the bacon produced. We have secured our cheapest gains, and an excellent quality of bacon from allowing the hogs only a limited amount of exercise in small outside yards adjacent to the pens, and feeding a limited ration of mixed meal accompanied with all the green food they will eat. By a limited meal ration, is meant an allowance slightly less than the hogs will eat if given the opportunity. We have found this method more economical than feeding meal on pasture, though it requires more labor. It is a notable fact, however, that hogs which have run at large until they weigh 100 pounds in thin condition, may be finished on almost any meal mixture and still produce firm bacon. This fact illustrates the marked influence of exercise upon firmness of bacon.

NOTES ON FOODSTUFFS.

It will invariably be found that a mixture of foods gives better results than a single kind. In the notes which follow, some of the principal pig foods are briefly discussed, and suggestions given regarding their combination with other foods.

Peas. Whole peas are very palatable, but entirely too wasteful, as the hogs do not digest them thoroughly. Pea meal is a valuable food, but should never be fed alone. The heavy, close nature of the meal renders it difficult to digest, and the pigs are very apt to sicken. It combines well with barley, or barley and wheat middlings. A few well ground oats may also be added. Peas are noted for the excellent quality of bacon which they produce.

Barley. This is a noted hog food in Europe; but some feeders in this country do not look upon it with favor. We have secured excellent results from barley, however, both in the amount of gain and the quality of bacon. For young pigs it should be mixed with wheat middlings, a very little barley being used at first, and the quantity gradually increased. For older pigs, peas or wheat may be added. Some succulent food, such as roots or green food, should always be fed with it; and skim-milk makes a great improvement. It is not generally regarded with favor as a food for breeding sows.

Wheat. This grain has a higher feeding value than barley, but requires mixing with other meal to get the best results. It combines very well with barley, or barley and middlings.

Oats. Owing to the amount of fibre in this food, hogs cannot digest it so well as can cattle. Oats are more suitable for matured breeding stock than for young or fattening pigs, though a few finely ground oats may be used in a mixture to give variety, and to lighten heavier meal, such as that from peas, wheat, or corn. For young pigs, they are better to have the coarser hulls sifted out.

Rye. Rye has a feeding value a little lower than wheat, and a little higher than barley. It may be used in practically the same way as wheat.

Corn. This is a fattening food, and is not conducive to the development of bone and muscle. When fed alone, it gives poor results in producing gain in weight; and its bad influence upon the quality of bacon has already been described. If fed at all, it should be mixed largely with barley or middlings, or both; and some form of succulent food or skim-milk should always be fed with it. Owing to its tendency to produce soft bacon, it should be used as little as possible for hog feeding, when bacon production is the object.

Middlings. This by-product is also called shorts, though some millers make a distinction between shorts and middlings. It is almost universally used for young pigs, and mixed with skim-milk when such is available. If very floury, it is safer to mix a little bran with it, or some finely ground oats with the coarser hulls sifted out, when used for very young pigs; otherwise it sometimes causes indigestion. Soaking for a few hours, or scalding, improves it for young pigs. It combines well with almost any kind of meal, and makes a good food for pigs of all ages.

Bran. The use of bran in pig feeding is rather limited. It contains too much fibre, and is rather too bulky to be fed in large quantity to pigs. Sometimes a little of it can be used to advantage for the purpose of diluting or lightening other foods, as has been indicated. It can be used in larger quantity for matured breeding stock, where the object is to hold the animals in light breeding condition.

Skim-milk. With the exception of whole milk, there is perhaps no food better suited to pigs of all ages than skim-milk. It is especially beneficial in the case of young pigs, and tends to promote the development of bone and muscle. For fattening purposes, milk has been found to have the greatest feeding value per 100 pounds, when not more than three pounds of milk are fed for each pound of meal. Fed in this way, as low as 327 pounds of skim-milk have proved equal to 100 pounds of meal. This is an exceptionally good showing, however. In Danish experiments, it required, on an average, about 600 pounds of milk to equal 100 pounds of meal; but in these cases a very much larger proportion of milk to meal was used than the proportion mentioned above. In feeding skim-milk, therefore, the feeder must take into account the relative cost of milk and meal, in deciding what proportions to feed.

A strong point in favor of skim-milk, is the excellent quality of bacon it produces. It tends to correct the evil influences of corn, when fed in conjunction with that food; and our experience is that when it is used, hogs produce firm bacon though kept in comparatively close confinement.

Whey. Though unsuitable for very young pigs, a limited amount of whey gives very good results after the pigs are three or four months old. We have obtained the best results from whey feeding by using only enough whey to make the meal into a thick slop. When fed in this way, we have found that it requires from 12 to 14 pounds of whey to be equal in feeding value to one

pound of meal. This is a very much higher feeding value for whey, however, than can be expected when it is fed in large quantity.

Its influence upon the firmness of bacon was very satisfactory; and it appeared to correct the bad influence of lack of exercise.

Sugar Beets. Hogs seem to prefer sugar beets to almost any other kind of roots. Some difference of opinion exists regarding the amount of roots that may be fed with profit to hogs. They should be fed in limited quantity to small pigs; but pigs weighing over 100 pounds live weight, will, in some cases, take five or six times as much roots as meal, by weight, and make very good gains. We have obtained our best results, however, from feeding equal parts by weight of roots and meal. The proportion of roots may be increased considerably, if thought advisable, as the hogs advance in weight.

In all our experiments, we have obtained very satisfactory results from root feeding, so far as firmness of bacon is concerned.

Mangels. Though not quite so high in feeding value, mangels compare very favorably with sugar beets for hog feeding. If the hogs have not been fed sugar beets, they will eat mangels very readily. Their influence upon the firmness of bacon is the same as that of sugar beets.

Turnips. Hogs are not so fond of turnips as of mangels and sugar beets; but if they do not know the taste of either mangels or sugar beets, they will eat a considerable quantity of turnips. Turnips are made more palatable by cooking, though it is doubtful whether cooking increases their actual feeding value, which is very similar to that of mangels. We have found the feeding of turnips along with a meal ration to give a firmer quality of bacon than when meal is fed alone.

Potatoes. Cooking is essential in order to get the best results from potatoes. If they can be cooked so as to leave them dry and mealy, hogs will eat them much more readily. They make a very palatable food when mashed and mixed with meal. Their influence upon the quality of bacon is also beneficial.

Artichokes. In some sections, this crop is very popular as a hog food. It is suitable, however, only for somewhat light, sandy soils. Artichokes may be planted in the late fall or early spring, in rows 21 to 24 inches apart, and from 12 to 18 inches apart in the rows. They are usually ready to feed about September 15th, and the hogs are turned in to dig them for themselves. Frost does not injure them, and usually enough are left in the ground for another crop, if it is thought advisable to leave them. When it is desired to eradicate them, the hogs may be turned on them again in the spring, and the plot subsequently sown with turnips.

Artichokes have a little higher feeding value than potatoes, and hogs are very fond of them.

Feeding Value of Roots. As has already been intimated, much of the feeding value of roots consists in their action upon the general health of the animal. They tend to prevent indigestion and constipation, and to promote general thrift. The results of our experiments, and of those conducted by other experiment stations, indicate that from 6 to 8 pounds of sugar beets, mangels, or turnips, are equivalent in feeding value to one pound of mixed meal; and that 4 to 4½ pounds of potatoes are equivalent to one pound of mixed meal. The meal equivalent of roots varies considerably, depending upon circumstances; but the figures given will serve as a general guide.

Rape. This is an exceptionally valuable food for swine, and may be pastured, or cut and fed to the pigs in pens. For fattening hogs, we have obtained best results from feeding about a two-thirds meal ration, and all the rape the hogs will eat. The hogs were kept in pens with small outside yards, and the

rape was cut and carried to them. This method of feeding gave more economical gains than fattening on pasture, and the bacon was of equally good quality.

For breeding sows, however, pasturing the rape is preferable, owing to the exercise it gives the animals. When on rape pasture, matured sows require little other food.

Young, growing sows, however, require a fairly liberal meal ration in addition to the rape.

Vetches. Hogs eat vetches even more readily than rape, but the vetches do not furnish so much food per acre. The vetches are ready for pasture a little earlier than the rape, and our common practice is to sow half our hog pasture with vetches, and half with rape. The sows are turned on the vetches first; and after this is eaten off, they are turned on the rape, and the vetch ground is sown with rape to furnish pasture late in the season.

Vetches may also be used as a soiling crop, as described under rape.

Hairy Vetch. The seed of this crop is very expensive. There is no doubt, however, that it makes an excellent pasture crop for swine. If not pastured too closely, it grows up quickly when the hogs are removed. For early spring pasture, it should be sown early in the fall, the latter part of August being a suitable time in most seasons. About $1\frac{1}{2}$ bushels of seed per acre are required.

It is our intention to modify our arrangements regarding our hog pasture, and to sow about one-third of it with hairy vetch and rye in the fall; and in the spring, sow one-third with common vetches, and one-third with rape. The hogs will then go on the rye and hairy vetches early in the spring, then on the common vetches, and then on the rape. The common vetch ground will be sown with rape as soon as the hogs leave it; and the hairy vetches and rye will make a second growth while the hogs are eating the first plot of rape. By this means we hope to provide pasture earlier in the season than our present plan permits.

Red Clover. This crop is best suited for pasture; and the hogs should be given quite a large range, or the clover will likely be killed out. It is especially useful for breeding sows.

Alfalfa. Where the soil and other conditions are suitable, alfalfa makes an almost ideal pasture for swine. Care must be taken, however, not to pasture too closely, or the crop may be destroyed. On the college farm, where a short rotation is practised and only a small plot is set apart for a hog pasture, we think we get more satisfactory results from annual crops.

Soja Bean. This crop makes a valuable soiling crop for swine, but is not suitable for pasture. It has a high feeding value, and is much relished by swine. The crop is usually sown at the rate of half a bushel per acre in drills two feet apart. The medium green variety is quite satisfactory for this purpose. It is usually sown in the early part of May.

FEEDING AND MANAGEMENT OF THE BOAR.

The age at which a young boar may be first used, depends a great deal upon his development. Some boars will serve a few young sows when only six or seven months old, and apparently not be injured by it. As a rule, it is safer not to use a boar before he is eight months old, and to use him as sparingly as possible until he is a year old. No hard and fast rule can be laid down, and the owner must exercise his judgment in the matter.

The quarters for the boar should be roomy, and he should have an outdoor lot in which to take exercise. Some boars are extremely active, and will take plenty of exercise in a comparatively limited space. Some are ver-

quiet and inclined to become too fat. It will be found beneficial with such a boar to force him to gather part of his living from pasture.

The boar should not be permitted to serve a sow more than once, and under no circumstances should he be allowed to run with the sows to which he is to be bred. This practice exhausts the boar, and is likely to result in small, weak litters. The best plan is to turn the sow into the boar's pen when she comes in heat, and to remove her immediately after she is served.

Boars frequently become lousy from serving lousy sows. Almost any of the standard sheep dips will kill lice if faithfully used. They should be mixed somewhat stronger than the directions call for. Coal oil is a very effective insecticide; but its tendency to blister the skin renders it objectionable. An excellent wash may be made as follows: Thoroughly mix 4 oz. of soft soap with 6 quarts of soft water; then add 8 oz. of naptha and mix again. This wash makes a good insecticide, and is also beneficial to the skin. The remarks on remedies for lice apply to all classes of pigs.

The food for the boar should be varied, nutritious, and moderately bulky. Succulent foods, such as roots in winter, and green food of some kind in summer, should always be fed with his meal ration. Succulent foods are necessary to keep him in good health. Finely ground oats are very suitable for the main part of his meal ration. An equal weight of middlings, or middlings and bran, added to the oats, makes a good combination. Small proportions of other kinds of meal may be added, if desired. He should be fed only what he will eat up clean; and if he is inclined to become fat and lazy, the food should be reduced.

FEEDING AND MANAGEMENT OF THE SOW.

A sow should not be bred before she is eight months old, and in many cases it is better to delay breeding two or three months longer. The development of the sow will influence the breeder in this matter.

During the period of gestation, sows of all ages should have abundant exercise. In summer, pasture should be provided for them. The winter quarters may vary with conditions; but the matter of exercise should never be neglected. Where only a few sows are kept, they can frequently be given the run of the barnyard, where they will take exercise rooting over the manure. They should have dry, well bedded sleeping quarters, that are free from draughts. When it is impossible to use the barnyard, it is more difficult problem. Perhaps one of the best methods is to make use of the portable pens, described in another place. These should be placed at least fifty yards from the feeding troughs. The door should face the south, and the pen should be kept well bedded. If the pen is banked about the outside with horse manure, draughts will be excluded, and the pen will be comfortable and well ventilated. This plan forces the sows to take exercise in going to and from the troughs; and exercise is absolutely essential to the production of strong, healthy litters. A large number of sows can be run together in this way. Care should be taken to provide plenty of trough room; and the troughs should be located on high, dry ground, or a platform should be arranged on which to place them.

A record should be kept of the date of service of each sow, so that the date of farrowing will be known in advance. Sixteen weeks from date of service to date of farrowing, is a sufficiently close calculation. A week or ten days before she farrows, the sow should be placed in the farrowing pen, so as to become accustomed to her changed conditions before farrowing. She should still be encouraged to take a reasonable amount of exercise, however.

The pen should be provided with guard rails, made of 2x8-inch planks placed with the edges against the sides of the pen about ten inches from the floor. These prevent the sow from lying against the partition and lessen the

danger of injury to the little pigs, which often find the space under the guard rail a very convenient refuge. A little cut straw or chaff makes the best bedding, as the little pigs are apt to become entangled in long straw, and find difficulty in keeping out of the way of the sow when she moves about. The sow should be handled, more or less, before she farrows, so that she may become accustomed to the presence of the attendant in the pen. A sow treated in this way, is less likely to become irritable and excited when the attendant enters the pen after she farrows. If everything goes well, she will require but little attention after farrowing, and the less she is interfered with, the better, except when it is absolutely necessary.

Many sows will take the boar a few days after farrowing. To breed a sow at such a time is a bad practice. No sow can do justice to herself and two litters of pigs at the same time. The sow usually comes in heat a few days after her pigs are weaned, and may then be bred again, if not too much pulled down by nursing. If she has raised a large litter and is very much emaciated, the chances are that she will produce a very small litter the next time, if she is bred immediately after her pigs are weaned. In such instances, she should be given three weeks or a month of liberal feeding to enable her to regain her lost strength and vitality before she is bred. Many a man has been puzzled to know why his sow, which had raised a fine, large litter, should drop down to only four or five puny pigs the next time. The reason is not far to seek. To produce a large, vigorous litter, the sow must be strong and full of vitality at the time of service.

In feeding the breeding sow during the period of gestation, the feeder should aim to keep her in good, strong condition, without having her become extremely fat. Many go to the other extreme, and keep their sows thin; and the thin sow either will not do justice to her pigs, or will become a mere wreck herself during the time she is nursing her litter—in fact, the chances are that both these things will happen. A sow may be kept in pretty high condition and still produce satisfactorily, provided she takes plenty of exercise.

When on good pasture, particularly clover pasture, sows require very little meal. As a rule, however, it is well to give them a light ration of ground oats and bran or middlings. It is well to avoid the heavier and more heating kinds of grain. If used at all, they should be used very sparingly. In winter, roots should take the place of the green food; and when the sows are fed outdoors as recommended, it is best to feed the meal dry. They will require little water outside of that supplied by the roots, during cold weather. In cold weather, a little corn, wheat, or rye may be added to the oats and bran ration when the sows are fed outside, as they can stand rather more heating food under these conditions. It is, perhaps, just as well to omit barley from the ration of a breeding sow.

When the sow goes into the warm farrowing pen, it is advisable to feed the meal in the form of a thick slop, and a moderate ration of roots should be continued. This system tends to prevent constipation, and a more or less fevered condition, which may result from changing from outdoor life to confinement. After she farrows, there should be no hurry about feeding her. If she lies quiet for ten or twelve hours, so much the better. At first, she should have little more than a drink. A very thin slop of bran and middlings, given in small quantities, will answer very well. The food may be gradually increased, and in the course of a week or ten days she will be on full feed. A good mother with a large litter requires very liberal feeding. If the litter is small, it may be necessary to reduce the quantity of food.

Many different rations are used for nursing sows. A very good ration can be made by mixing two parts of finely ground oats with one part of bran and one part of wheat middlings, and allowing the food to soak between feeds. A few roots should also be fed. Sweet skim-milk is good. Some feed

a small quantity of oil cake, and no doubt it is beneficial in the mixture. The heavier grains should be fed very sparingly, if at all; and barley should be omitted, as it is not a good milk former.

After the pigs are weaned, the food should be cut down to check the secretion of milk. Dry oats are a safe food for a few days after the pigs are taken away. If the udder gets very full, it is a good plan to turn the sow in with the pigs once a day for a few days.

FEEDING AND MANAGEMENT OF YOUNG PIGS.

When the little pigs are born, the attendant should be on hand and see that they are placed on their mother to suck as soon as possible. Some prefer to put the pigs in a box or basket, for the first day or two, taking them out at short intervals to suck. If the pigs are strong, however, and the sow is a reasonably good mother, it is better to leave them with her.

By the time the pigs are three weeks old, they will have learned to eat. If at all possible, they should be given access to another pen, in which is kept a small trough. Here they can be fed a little skim-milk, with a very little middlings stirred into it. The quantity of middlings can be gradually increased as the pigs grow older. If they can be taught to nibble at roots during this time, all the better. A little whole wheat, or soaked corn, scattered on the floor of the feeding pen, will cause them to take exercise while hunting for it. Exercise is very important for young pigs; and every possible means of securing it, should be adopted. If they are kept in a small pen with the mother, some of the best of them are apt to become too fat, and are likely to sicken and die. Pigs that come in the spring, however, or early fall, are more easily managed than winter litters, as they can be given outdoor exercise. If the sow is turned out with her pigs, it is not well to give her a large range, as she is likely to travel too far and tire the pigs too much.

The pigs may be weaned at six weeks old. If skim-milk is not available, it is generally better to defer weaning until eight weeks old. If they have been taught to eat as described, they will go right on eating and suffer but little from weaning. Skim-milk and middlings make about the best food for young pigs at this time. The middlings should be soaked a few hours before feeding, or, better still, scalded. If fed freshly mixed, they are likely to cause indigestion. A few finely ground oats with the hulls sifted out, make a good combination with middlings. When the pigs are first weaned, it is better to feed four times a day, feeding only what they will eat up clean before leaving the trough. When well started, they may be changed to three feeds a day.

When the pigs are three months old, a little ground barley may be added to the meal mixture. At first, the barley should constitute not more than a fifth of the total ration; and it can be gradually increased as desired, or other foods added as indicated under notes on foodstuffs.

It is important to teach young pigs to eat a few roots as early as possible; or, if it is too late in the spring for roots, some form of green food should be supplied every day.

PART V.—MISCELLANEOUS.

Cooking Food for Swine. A great many experiments have been conducted with cooked food for swine at the various experiment stations; and for this reason we have done practically nothing in this line of work, with the exception of cooking turnips. Taking the results of tests from different stations, we find many contradictory results, sometimes the cooked food scoring an advantage, but oftener, the uncooked taking the lead. So far as can be made out from the results, it would seem that cooking does not increase the feeding value of meal; and the weight of evidence is in favor of the theory that cooking decreases the digestibility of meal. Potatoes, however, appear to be improved by cooking. Turnips are rendered more palatable by cooking; but it is doubtful whether their feeding value is increased thereby. If it is desired to feed a large quantity of turnips, no doubt cooking is an advantage. In the case of sugar beets and mangels, which the hogs eat readily in the raw state, it is very doubtful whether cooking pays. On the whole, therefore, cooking apparently tends to make foods more palatable in some cases; but its effect upon the digestibility of foods appears to be injurious, rather than beneficial. Potatoes, however, seem to be an exception to the general rule, and are believed to be more digestible, as well as more palatable, when cooked.

Soaked, Wet and Dry Meal. So far as can be gleaned from experiments to date, soaking meal for several hours before feeding appears to improve its feeding value. It is doubtful, however, whether wetting the food just before feeding has very much influence. One of the difficulties we have experienced in feeding dry meal, is the prevention of waste, particularly in outside feeding, where a rather large number of hogs are fed together. In such cases, considerable meal is thrown out of the troughs and trampled into the earth. Where only a few hogs are fed together, especially where they are fed in a pen with a cement floor, there is very little waste. Where the meal is fed wet, there is danger of forcing a hog to take more water than it requires, especially in cold weather. This is most important in the case of breeding sows, especially where they are fed outdoors, as recommended elsewhere. For breeding sows fed outdoors, we would recommend dry meal. There may be a waste of meal, but we believe this will be more than paid back when the pigs are born. The whole matter, after all, is largely one of judgment, and calls for careful study of the conditions under which the feeding is done. For ordinary winter feeding, we have had very satisfactory results from mixing the dry meal with pulped roots, and allowing the mixture to stand from one feeding time to another. Both roots and meal seem to be made more palatable in this way. In warm weather, there is much less danger of supplying more water than is required.

Relation of Live Weight to Economy of Gain. In various experiments it has been shown that the amount of meal required for a pound of gain in weight steadily increases as the pig becomes heavier. Our experiments with pure-bred swine bring out this point very clearly, as the following statement shows:

Live weight of hogs.	Meal required for 100 lbs. increase in weight.
lbs.	lbs.
54 to 82.....	310
82 to 115.....	375
115 to 148.....	438
148 to 170.....	455

Prof. W. A. Henry, in his book "Feeds and Feeding," gives a very interesting table under this head, which he compiled from the results of many experi-

ment stations. This table indicates that hogs weighing from 150 to 200 pounds require 482 pounds meal for 100 pounds gain; from 200 to 250 pounds, 498 pounds meal; and from 250 to 300 pounds, 511 pounds meal. It will be seen from these figures that the weight at which the Canadian packer wants the hog, is just about the limit of profitable feeding.

Correctives. Swine appears to have a craving for what might be called unnatural substances. This is especially true of hogs that are kept in confinement, which will eat greedily such substances as charcoal, ashes, mortar, soft coal, rotten wood, etc. It is probable that some of these substances are not good for hogs; but there is no doubt that charcoal and wood ashes have a beneficial effect, the former being greatly relished. It is good practice to supply charcoal, especially during the winter months. Wood ashes, or a mixture of wood ashes and salt, may be used in place of charcoal; but charcoal is preferable. Sods make a very fair substitute for charcoal. A waggon load or two of sods placed conveniently near the piggery, so that the feeder can throw one or two into each pen occasionally, will be found well worth the labor involved. Pigs that are outdoors in summer, and have access to earth and vegetable matter, have little need of other correctives. The term "correctives" is used for want of a better; but such substances as those described, appear to correct, or to prevent, derangement of the digestive organs.

The Feeder. To make a successful feeder, a man must have a love for the animals under his charge, and be willing to sacrifice his own comfort and convenience to theirs. He must possess sound judgment, and must make a study of the animals under his care, so that he will be able to detect the first signs of anything wrong. He must have a knowledge of the foods suited to different ages, sexes, and conditions, and his judgment will be shown in using these foods to secure the best results. In spite of all directions which may be given, emergencies are always arising to test the judgment and resourcefulness of the feeder. The suggestions, therefore, which have been offered in this bulletin, are intended as a general guide, but they cannot supply the place of skill and judgment on the part of the feeder.



Ontario Agricultural College and Experimental Farm.

A COMPARISON OF THE BACTERIAL CONTENT OF CHEESE
CURED AT DIFFERENT TEMPERATURES.

By Prof. F. C. Harrison and Prof. W. T. Connell.

The following investigations were made partly at the Agricultural College, Guelph, and partly at the Eastern Dairy School, Kingston, the latter being done under the direction of the Commissioner of Agriculture and Dairying for the Dominion. The object was to determine the bacteriological conditions existing in Canadian Cheddar cheese when cured at different temperatures; to note the relationship existing between the bacterial contents and other curing agencies; and to learn, if possible, some lessons of practical value for those engaged in the production of cheese.

SOURCES OF CHEESE ANALYSED.

The cheese subjected to analysis were of two distinct groups. The first group consisted of those made and kept at the factory at Carp, Ontario, during the seasons of 1899 and 1900. This lot comprised 28 cheese in all, 14 being analysed in 1899 and 14 in 1900, each cheese being examined a number of times at various intervals. One-half the cheese examined each season was kept in an insulated curing room at a temperature varying between 60 and 65 degrees Fah., the average for both summers being 62.2 degrees Fah., the maximum recorded being 67 degrees and the minimum 56 degrees. The remaining half was kept in an ordinary curing room in which no attempt was made to control the temperature. The average temperature of this room in 1899, while containing the cheese analyzed, was as follows: Last fifteen days of June, 68.7 degrees Fah.; July, 70.5 degrees Fah.; August, 70.8 degrees Fah. The average temperature of this room in 1900 was: July, 72 degrees Fah.; August, 69 degrees Fah.

The temperature of the insulated room, which was isolated from the ordinary curing room, was regulated by a sub-earth duct and by the use of ice in racks. Full details as to methods of structure and insulation of the ordinary curing room and factory are given in the reports of the Commissioner of Agriculture and Dairying for 1899.

The second group of cheese consisted of those made at the Agricultural College factory, Guelph. The work in this group related to the effects of ripening cheese at a temperature of about 40 degrees Fah. throughout the whole period of curing, and ripening for one and two and three weeks in an ordinary curing room, and then removing to cold storage—both compared with ripening for the full period in the ordinary curing room.

In these experiments five flat Cheddar cheese were made from each curd, and were marked A, B, C, D and E. The cheese were put directly into ice cold storage, where the temperature averaged 37.8 degrees Fah., and the percentage of humidity averaged 91.6 degrees for the season. The extreme variation in the monthly average temperature of the cold storage from April to November was 4 degrees; and the variation in the humidity was 4 degrees.

The other five cheese were put into the ripening room, and transfers were subsequently made from the ripening room to cold storage, as follows: The B cheese at the end of one week; the C cheese at the end of two weeks; and the D cheese at the end of three weeks. The E cheese were left in the ripening room and ripened in the ordinary way at an average temperature of 63.8 degrees Fah. for the season. The average percentage of humidity in this room was 79.1 degrees for the season. The average monthly variations in the temperature of this room were from 86.6 degrees in July to 58.7 degrees in November. The humidity varied from 84.3 per cent. in August to 73.7 per cent. in October. The temperature of the air outside averaged 56.9 degrees for the season. The average maximum temperature outside ranged from 85.8 degrees Fah. in July to 39 degrees in November.

The average minimum outside temperature ranged from 59.6 degrees in July to 24 degrees in November. The month of July was the hottest month of the season, and August was next, with maximum and minimum averages of 79.7 degrees and 56.3 degrees. June averaged 77.4 degrees and 53.5 degrees for maximum and minimum temperatures.

It should be remembered that it is not strictly accurate to take the average temperature by adding together the maximum and minimum temperatures and dividing for the average, as there is often a large variation in temperature, and the temperature for the day would, as a rule, more nearly approximate the maximum figure for a longer period of the day than the average.

TAKING OF SAMPLES.

Samples from the Carp factory were taken by Mr. Woodard, the maker, under the direction of one of us. Samples were always taken of cheese of the same day's make, kept in the regulated and variable rooms, so as to have a contrast between cheeses of the same age. The samples analyzed and compared were always taken from cheese of the same day's make. The samples were taken with a thoroughly cleansed cheese borer and immediately placed with great care in sterilized test tubes, always two

of each cheese, in order to have a duplicate in case any accident should befall one of the samples. The cheese borer was cleansed before using to obtain the second specimen; and the test tubes were plugged, packed on ice and forwarded to Kingston, being received about eighteen hours after they were taken.

At this point the analyses might not be entirely reliable; for while specimens usually came in good condition, still on several occasions, the ice in the packing box was completely melted, and the contents of the box were almost at the temperature of the air—which was likely due to the placing of the box in some exposed place by the carriers. The exact effects of such a change in temperature could not be accurately gauged; but when it was considered to be a factor, the results of the analysis were excluded from the tables.

The samples of cheese taken from the College factory, Guelph, were obtained in a similar way, except that it was not necessary to pack them on ice, as the laboratory is only a few minutes' walk from the factory. These samples were promptly taken from the factory to the laboratory and immediately analyzed.

A source of error in the quantitative bacteriological analysis of cheese is the fact, repeatedly determined in control analyses, that plugs from different parts of the same cheese, of the same age, vary as much as 30 per cent. in their bacterial content. Further, even in the same plug, portions of equal weight sometimes show as high as 20 per cent. of difference in the number of bacteria contained in them. A few examples of this fact may be given. A plug from cheese of July, 1902, age 12 days, gave 144,000,000 per gram. From cheese made in September, 1902, the age being 40 days, one plug gave 27,000,000 per gram; and another from a different part of the cheese gave 22,500,000 per gram. From cheese of July, 1902, age 12 days, the upper portion of a plug gave 210,000,000 per gram and lower portions of the same plug gave 293,000,000.

We have also noticed in abnormal cheese, made by adding a culture of a gas-producing germ to the milk, that in the separate particles of curd which unite to make the cheese, the exterior surface of each particle contains a larger number of bacteria than the interior thereof. Thus, in an analysis of cheese made in November, the exterior, or outer surface, of the curd particles gave 456 millions per gram, while the interior thereof gave 51 millions per gram; and again, at a later date, the exterior and interior of the curd particles in the same cheese gave respectively 67 millions and 37 millions per gram.

These examinations, which are typical of many others which we have made, show that there is not an even distribution of bacteria throughout the substance of a cheese, and it would, therefore, seem necessary to modify somewhat our methods of analyses.

METHODS OF ANALYSIS, ETC.

Methods followed in the Analysis of Samples. The samples sent from Carp factory to Kingston were all subjected to an examination by the differ-

ent methods of culture. Control microscopic examinations of the cheese were frequently made to determine if there were in them any forms which did not develop in the culture plates. No forms were found, however, except those which developed in the cultures.

The medium used for the culture of the bacteria contained in the cheese from the Carp factory was the ordinary beef-peptone-gelatine (12 per cent.). Agar proved entirely unsuitable for the requirements of the investigation. The cultures were made aerobically, the few cultures made anaerobically not showing the development of any forms except those found in the ordinary plates.

The medium used for the Guelph cheese was peptone-whey gelatine (10 per cent.), with or without the addition of blue litmus, precipitated chalk, or rosolic acid. Usually two plates were made from beef-peptone lactose gelatine. For each sample, from 5 to 7 plates were made.

KINGSTON METHOD.

As the methods followed at Kingston were somewhat different from those used at Guelph, we shall briefly outline them.

The Kingston Method. Usually one-tenth gram of the interior of the plug was taken and thoroughly pulverized in a sterile mortar with coarse granulated sugar. The sugar had been previously sterilized by soaking under ether for 2 to 7 days and then carefully evaporating the ether.

The finely pulverized mass was then washed with a measured amount of sterile water into a sterilized shaking bottle, and this was kept constantly agitated so as to secure a thorough and even admixture. The amount of dilution required varied with the age of the cheese. It was found that for green cheese a dilution of one part of cheese in from 20,000 to 100,000 parts of sterile water was required. This dilution was commonly effected as follows: 100 cc. of water were used to dissolve the powder and wash it into the first sterile shaking bottle. After this bottle had been thoroughly agitated for at least three minutes, 5 cc. were quickly removed with a sterile pipette and added to a second shaking bottle. To this was then added as many cc.'s as would make the dilution required. By this means one avoided the use of a large amount of diluting fluid. From the second bottle, after prolonged agitation, measured quantities were quickly added to melted gelatine. After a careful admixture with the gelatine culture was secured, plates were poured in the usual manner. These plates were incubated at from 21 to 22 degrees C. till all development had ceased. The colonies which had developed were then carefully counted over the entire surface of the culture plates, and the various colonies identified as to their species. Repeated sub-cultures in various medi-

had often to be made to establish the identity of a species; but this work was rendered somewhat easier by the marked predominance of the bacillus *acidi lactici*.

GUELPH METHODS.

The Guelph Methods. One-half or one gram of cheese was taken and pulverized in a sterile mortar, with ten grams of powdered glass thoroughly sterilized; and 50 cc. of sterilized warm water (37 degrees C.) was gradually added, with constant stirring, to make a fine emulsion. And we think that by taking cheese in considerable quantity from different parts of the interior of the plug and pulverizing the samples with sterilized powdered glass, using ten grams of powdered glass for each gram of cheese, more accurate results were obtained than could be secured by the methods followed in former investigations. When these larger amounts of cheese were used, the quantity of the diluting fluid had to be considerably increased, and the labor of preparing the samples was much greater; but undoubtedly the results obtained were more accurate and gave a more reliable estimate of the bacterial content of the cheese. For the larger number of the Guelph analyses, one gram of cheese was used. In a few instances five grams were used.

From the first dilution, one or two cc. were transferred to a measured amount of sterile water in a sterilized flask. After thorough shaking, a measured quantity was again transferred to a measured amount of sterile water in another sterilized flask; and, after further shaking, various quantities of this third dilution were added to the culture media. For transferring portions of the mixture from one dilution to another, straight-sided (Mohr) pipettes were used, and great care was taken to keep the liquid in the pipette in motion; for if not kept in motion, the particles in suspension would settle in a short time at the bottom of the pipette and thus interfere with the accuracy of the results. The amount of dilution varied with the age of the cheese from 750,000 to 100,000 parts of sterile water to one part of cheese. The plates were levelled on a nivellating apparatus, cooled with ice, and subsequently placed in a cool incubator at 20 degrees C., where they remained till all development had ceased. The colonies were counted by means of a Jeffers counter; and computations were made therefrom.

De Freudenreich's method of obtaining liquefying germs by making surface cultures from the last dilution was occasionally used.

As previous work upon the bacterial flora of cheese had failed to show any obligate anaerobes, no anaerobic methods of culture were used.

BACTERIA FOUND.

The bacteria found in the cheese at Guelph are divided into four classes:

A. True Lactic Acid Bacteria, of which several varieties differing only in slight particulars were found. All were bacilli, usually arranged as diplobacilli, at times in short chains. The commonest species was undoubtedly the *B. acidi lactici* (Esten).

B. Gas-forming Bacteria. These were mainly varieties of the *B. coli communis* and the *B. lactis aerogenes*, although once or twice a species which in most particulars resembled *Proteus vulgaris* was isolated.

C. Indifferent Bacteria. Various sarcinae, particularly *Sarcina lutea*, some yeasts, and torlae were found. *B. subtilis* and one or two other casein digestors were isolated; but their action, on account of their small numbers, must be considered insignificant. Further, none of these latter species was constantly present; so their action may be regarded as having little or no influence in the curing of the cheese.

In this class one of us included all bacteria, not lactic acid or gas-producing.

D. Digesting Bacteria. By means of surface gelatine plates and emulsions of cheese, heated in order to destroy all vegetative forms and thus leave only spore-producing species, constant endeavor was made to isolate organisms belonging to this class.

In former analyses of cheddar cheese, one of us found seven different species of digesting or liquefying germs, the commonest form being *B. butyricus*. In this investigation, liquefying bacteria belonging to the *subtilis* group, *M. aureus lactis*, *M. varians lactis*, *B. fulvus* and *B. halofaciens* were isolated. Most of these species are liquefying, chromogenic forms. According to Conn, the second named is a distinctive dairy type which he found very frequently in milk. We may add that it has been isolated from the milk-ducts; and, in this connection, may note Harding's opinion, that the enzymes from liquefying bacteria, isolated from the udder of cows, may have some influence in the ripening changes of cheddar cheese. However, as already pointed out, none of these species are constantly present in cheese. Hence their action must be insignificant.

As may be seen from the appended tables, the lactic acid bacteria were the only constant bacteria present in vary large numbers.

COMMERCIAL OPINIONS ON THE KINGSTON CHEESE.

Commercial Opinions on the Kingston Cheese. Commercial examinations of the same batches as those analysed were made at different dates. Part of the cheese was examined in Montreal in November, 1899, where the cheese had been held in cold storage from the early part of September. Cheese from the non-regulated room, made on and after the 29th of July, were de-

stroyed by fire on the way to Montreal; so no comparison can be made between the cheese of these days' make kept in regulated and in non-regulated curing rooms.

COMMENTS OF THE JUDGES UPON KINGSTON CHEESE MADE IN 1899 :

†Date.	Cheese in regulated room.	Cheese in non-regulated room.
June 22—	Body texture and flavor better.	Tender; on verge of going off.
July 1—	Better body and flavor and more waxy.	Not clean.
July 7—	Nearly alike; rather better body, and slightly better cheese.	Hardly clean; tender.
July 13—	Clean; waxy.	Not quite clean; body tender.
July 19—	Good cheese.	Pasty; not clean.
July 29—	Off flavor.	{ Not reported owing to destruction in transit.
August 10—	Good flavor.	

†For the bacterial data of these cheese, please refer to the same dates in the tables of analysis commencing on page 14.

COMMERCIAL RATINGS OF THE KINGSTON CHEESE MADE IN 1900.*

Date.	Room.†	Vat.	Body. In Order of Merit.	Flavor. In Order of Merit.	Remarks.
†July 7....	1	.....	.....	1	Best cheese of entire lot.
" 6....	1	.....	.....	2	Slightly fruity.
" 5....	1	.....	.....	3	Off flavor.
" 7....	2	.....	.....	4	Tallowy.
" 6....	2	.....	.....	5	Fruity flavor.
" 5....	2	.....	.....	6	Off flavor.
" 19...	1	1	1	1	Body about alike in all cheese in room 1.
" 19...	1	3	2	2	Off flavor.
" 19....	2	1	3	3	} Cheese from vat 3, room 2, contained slightly more moisture than cheese from vat 1, room 2.
" 19....	2	3	4	4	
" 18....	1	1	1	1	Less moisture; better flavor than other cheese of this date.
" 18 ..	1	3	2	2	Off flavor; more moisture than in other cheese of this date.
" 18....	2	1	3	3	
" 18....	2	3	4	4	Poorest of lot. Cheese of July 19th equal to that of July 6th in flavor.

* These cheese were not scored according to any scale.

† For the bacteriological data of these cheese, please refer to the same dates in the tables of analysis commencing on page 14.

‡ No. 1 is the regulated room and No. 2, the non-regulated room.

SCORINGS OF THE GUELPH CHEESE.

Quality of the Guelph Cheese. These cheese were scored according to the following scale of points: Flavor, 40; closeness, 15; even color, 15; texture, 20; finish, 10; total, 100. They were all scored 10 points for finish, in order to make the results more uniform. Six prominent cheese buyers of Montreal and four Ontario buyers did the scoring; and the following table shows the average of all the scorings made by months:

†	Flavor.	Closeness.	Even color.	Texture.	Total.
	Max. 40	Max. 15.	Max. 15.	Max. 20.	Max. 100.
April cheese.	Av.	Av.	Av.	Av.	Av.
A.....	35.7	14.7	14.2	17.6	92.3
B.....	35.5	14.6	14.1	17.4	91.5
C.....	34.5	14.7	14.1	17.4	90.7
D.....	35.8	14.3	14.1	17.7	91.9
E.....	25.6	14.1	11.5	15.5	76.7
May cheese.					
A.....	36.1	14.7	14.1	17.9	92.9
B.....	35.9	14.4	13.7	17.8	91.8
C.....	35.4	14.5	13.8	17.5	91.2
D.....	35.8	14.4	13.8	16.9	90.9
E.....	33.9	13.9	13.9	16.2	87.9
June cheese.					
A.....	33.5	14.8	14.5	17.4	90.2
E.....	31.6	14.1	14.0	15.2	84.9

†For the bacterial data of these cheese, please refer to the same dates in the tables of analysis commencing on page 14.

The first scoring of the cold-storage cheese (A, B, C and D in the table) was made when they were from three to four months old; and they were scored several times thereafter. The cheese ripened in the ordinary room (E in the table) were scored the first time when they were from six weeks to two months old, and again at intervals of about one month after the first scoring, until it was considered that there would be no advantage in keeping them for a longer time.

REMARKS ON THE ANALYTICAL RESULTS.

A study of the tables of analysis (page 14 to end) shows that each day's cheese differs in its quantitative bacterial content from the cheese of every other day's make. This is not to be wondered at, when we remember that each day's milk differs more or less from that of every other day, and that little differences in handling are of daily occurrence. Such differences in the milk, in the handling of the curd, and in the use of various temperatures, no doubt account for the differences in bacterial content. A perusal of the tables shows a very great difference in the initial number of the bacteria in cheese. The lowest number found in cheese under four days old was 110,750,000 per gram; and the highest number in cheese of the same age was 635,000,000 per gram.

It may also be noted that the bacterial content declines more rapidly in the cheese of some day's make than it does in others. This may also be due

to different conditions, such as those already mentioned, and to the influence of the products of bacterial activity upon the living organisms.

The tables also show that the bacterial content of normal cheese is usually at its highest at the time of taking from the press or during the first few days after the cheese are placed in the curing room. In other words, the bacteria in cheese are the survivors of bacteria in the curd. This statement, however, does not always hold good; for we may have cheese in which the acidity has not developed to such an extent as is usually considered desirable; and in such a case there will likely be a period of bacterial development after the cheese is placed in the curing room. It has also been claimed that there is more likely to be bacterial development when the cheese are moister than usual; but, in our investigations, no difference was observed in the quantitative analysis of cheese coming from "moist" and from "ordinary" vats.

By the experimental data given here, the number of bacteria was shown to be at its maximum when the cheese were taken from the press; and following this period we had (taking into account the factors leading to error in analysis) a continuous and gradual decline in the bacterial content. This decline continued till about the 100th day, when the contents seemed to remain fairly stationary for some time. Following this period, in which the bacterial content remained at a fairly constant level, we had a gradual decline; but in some cheese a year old, from 10,000 to 500,000 lactic acid bacteria were found.

The decline was more gradual and the contents remained high for a longer period in the cheese kept in ice cold storage at an average temperature of 40 degrees than in cheese kept in an ordinary curing room. This statement, but in a lesser degree, is also true of cheese kept in cool or regulated rooms. Without exception, we found a higher bacterial content in the cheese kept in the ice cold storage and in the regulated room, and also noted that there was better body and flavor in the cheese from these rooms, than in those from the unregulated curing rooms. This factor of higher bacterial content must, therefore, be one of considerable importance, particularly as regards the flavor of the cheese. The proportion of lactic acid bacteria to undesirable organisms is much greater in cold-storage and cool-storage cheese than is usual under ordinary conditions; and this ratio remains constant for a greater length of time in the refrigerator cheese than in either of the others; and it is obvious that a cheese with the ratio of 97 lactic acid bacteria to one undesirable organism will be of better flavor than a cheese kept in an unregulated curing room with a ratio of 47 lactic acid bacteria to one undesirable one. These ratios are in some of the cases, given in the tables of analysis.

The lactic acid bacteria are practically the only organisms present in normal cheese, and certainly the only bacteria in each particle of it; so it must be the only microbe of much importance in good cheese. It is true that gas-forming bacteria and other undesirable kinds were found in nearly every cheese we examined; but they were usually present in the samples taken at an early date, and very exceptionally in those of later date. They seldom, if ever, increase in numbers.

The presence of the proteus form in the cheese of July 29th, even though it did not increase in numbers, likely accounts for the cheese of that day going "off" in flavor. Such forms are favored by the warmer temperature of the variable room; but the large numbers of the lactic acid bacteria prevent their growth and soon destroy most of them. Gas-forming bacteria do multiply and are found in large numbers in open cheese, and especially in cheese in which this taint develops early. This may be due partly to a lack of acid in the cheese, and partly to various other defects in the manufacture. Both *B. Coli* and *B. lactis aerogenes* produce mottling. Conclusive evidence of this fact was obtained from a number of our experiments, made by using starters of these gas-producing organisms and manufacturing cheese therefrom. The mottles were most marked at the places where the particles of curd came together; holes and cracks also developed at these places, and it was evident that the gas produced by these organisms, particularly the hydrogen, had a marked bleaching action upon the curd. We also found that the white particles produced by bleaching contained much larger numbers of the gas-producing organism than other portions of the cheese.

The results of more detailed experiments upon this phase of the question will be given in a subsequent publication.

The lactic acid bacteria decline most rapidly in cheese kept in a room with a variable temperature; and when such decline takes place, any other bacterial species present is likely to multiply and produce its characteristic effects. This, perhaps, accounts for cheese going "off" in flavor when they become quite old; and such an undesirable result is much more likely to occur in cheese from a room of variable temperature than from cool or cold rooms, regulated by any of the methods adopted for the purpose. It may also be possible that abnormal flavors are produced by organisms which can grow only after a certain decomposition effected by a previous organism, the first furnishing a suitable food for the second. We do not yet know whether lactic acid bacteria render cheese suitable or unsuitable for the growth of any other species. The neutralization of the lime salts of the cheese by the generated lactic acid may at times bring about a condition suitable for the development of other bacteria which may be present in a dormant condition. The metabolic phenomena in cheese certainly require further study.

As cheese become older, the lactic acid bacteria gradually lose their power of producing lactic acid when introduced into fresh milk. No morphological change can be detected in these bacteria. Colony formation on culture media remain quite characteristic. Lloyd has obtained similar results. He, however, thinks that lactic acid formation still goes on in the centre of the cheese; but, in our opinion, these bacteria are simply persisting forms of the contained bacteria. Reference to the tables shows that, on several occasions, we had an apparent increase of bacteria in cheese, several weeks old, kept at a temperature of 40 degrees Fah.; and we explain these results as due to the unequal distribution of bacteria in the cheese; for, by a number of experiments, we proved that there could be no increase of the lactic acid bacteria in milk kept at 40 degrees Fah. Some of the experiments on this point may be referred to.

On the 26th of November, 1902, 80 cc. of sterilized milk were inoculated with 2 oese of a 24-hour old bouillon culture of the lactic acid bacillus; and plates made from this mixture gave 430 colonies per oese. On the 3rd of December, this milk, at a temperature of 40 degrees Fah., was again examined and showed 150 colonies per oese; and at the same time, one drop of the milk was diluted in 12 cc. of sterilized water and two colonies per cc. of this mixture developed. On the 16th of December, the temperature being the same, 42 colonies per cc. and 2 colonies per oese respectively developed. The milk was then transferred to the incubator at 20 degrees C., and coagulated in 24 hours. Other experiments with gas-producing germs had similar results—there was no increase in the number of bacteria held at 40 degrees Fah. This experiment was repeated with lactic acid bacteria and gas-producing bacteria, with similar results, viz., that there was no increase in the numbers of bacteria in milk held at 40 degrees Fah. Consequently, there could be no increase in the number of lactic acid and gas-producing bacteria in cheese held at this temperature.

BACTERIAL CONTENTS AND RIPENING PHENOMENA.

Bacterial Contents and Ripening Phenomena. The question of the really active agent or agents in the curing of cheese is still an open one. If bacteria are the active agents, then lactic acid bacteria must be the agents in the process. De Freudenreich appears to have shown that these bacteria can produce an increase of the soluble nitrogenous products in the casein of milk, provided calcium carbonate is present. Klein and Kirsten stated that, by the use of starters, normal cheese can be made from pasteurized milk (which is free from enzymes); but Boekhout and Vries were unable to produce normal Edam cheese from aseptic milk with the addition of a culture of the lactic acid bacillus; and Chodat and Bang did not obtain an increase in the quantity of soluble nitrogen by growing lactic acid bacteria on coagulated casein; so, taking these facts into account, we are bound to admit that there still exists more or less doubt as to the ability of the lactic acid bacillus alone to produce an increase in the amount of soluble nitrogen.

Babcock and Russell attributed to Galactase (an enzyme which they discovered in milk) the principal influence in the ripening of cheese; but De Freudenreich has shown that 0.5 per cent. of lactic acid enfeebls the action of galactase; and the very considerable amount of acid in normal Canadian cheddar cheese must still more diminish the action of this ferment, as the percentage of acidity or acid salts in ordinary cheese of this kind varies at different ages from 0.76 per cent. to 1.5 per cent.

Babcock and Russell (subsequent to the discovery of Galactase) and Jensen simultaneously proved that the pepsin in rennet increased the higher decomposition products, such as albumoses and peptones, in cheese; and there is the well-known fact that cheese-makers increase the amount of rennet when they want a fast-curing cheese.

Rennet acts more quickly and better than galactase in acid solutions; and it seems that the function of the lactic acid bacteria, whose growth in milk is

so carefully fostered by the cheese-maker, is to create the requisite acidity in order that the pepsin of the rennet may exercise its digestive action on the cheese; and it appears certain that the fundamental curing changes commence during the maturing of the curd in the vat, but do not make themselves manifest till later.

PRODUCTION OF FLAVOR.

Production of Flavor. The most important characteristic of cheese is its flavor. Buyers of cheddar cheese, especially, judge very largely by the flavor; and no other characteristic counts for so much in estimating the market value. It is, therefore, necessary that the factors which contribute to the production of flavor should be thoroughly understood.

B. coli, *B. lactis aerogenes*, *Proteus*, etc., are sometimes present in milk and cheese, and are to be guarded against, on account of the abnormal flavors which they produce; and other species are occasionally found, but in such small numbers that they produce little or no effect upon the flavor of the cheese; but from the analyses here presented, it is evident that the lactic acid bacillus is the only species of organism which is of much importance to cheese-makers. Generally speaking, the flavor of the cheese depends mainly upon this organism, when it is present in large numbers, and in what we ordinarily term pure culture, we get the best flavor. It is only when the cheese breaks down under the influence of the enzymes in the rennet, after the ground has been prepared by the lactic acid bacteria, that flavor develops. The rapidity and character of the ripening process, involving the life of the lactic acid bacteria, largely depend upon the temperature at which the cheese is kept; and the most important factor in the control of temperature is a well-regulated cold or cool room.

The quality of the cheese in the Guelph experiments was in the order of placing in cold storage as regards time—that put in directly from the hoops being the best. In the Kingston experiments, the cheese in the regulated room was superior to that in the ordinary non-regulated room; and in all these best cheese, the most noticeable fact was the high number of lactic acid bacteria which they contained and the length of time these organisms remained alive in them.

The similarity of germ content in the same kind of cheese, though made in various localities, has a bearing on the question; and we have found that in normal cheese from various parts of the Province, the lactic acid bacillus is the only species that is constantly found in large numbers.

CONCLUSIONS.

1. The presence of certain undesirable bacteria sometimes produces "off" flavors in cheese. The *Proteus* form found in the cheese of July 29th was likely the cause of the cheese of that date being abnormal in flavor.

2. In nearly all the cheese examined, gas-producing, digesting or indifferent species of bacteria were found; but they always were in insignificant numbers and soon died out.

3. Undesirable bacteria such as are found in cheese seem unable to grow at a temperature of 40 degrees Fah. Consequently, the flavors in cheese caused by the growth of bacteria therein do not increase in cold storage.

4. In normal cheese, the greatest bacterial content is usually found when it is one day old, though occasionally it is at the maximum in cheese from two to five days old. At this period the number of bacteria sometimes reaches the enormous total of 625,000,000 per gram.

5. Following this period, we have a gradual and continuous decline in the number of bacteria as the cheese get older.

6. The bacterial content remains high for the longest time, and the decline is most gradual, in cheese kept in ice cold storage, at an average temperature of 40 degrees Fahrenheit. In cheese kept in a cool, well-regulated room, similar results occur, but the decline in the number of bacteria is more rapid. As this higher bacterial content constantly corresponds with a better flavor in the cheese, we infer that it is the chief factor in determining the flavor of cheese properly made from good, pure milk.

7. Lactic acid bacilli are practically the only bacteria in normal cheese during the ripening process; and throughout the process they gradually and constantly decline in number. As the curing changes are manifested only after the lapse of some time, these changes must be influenced by the products of the early activity of the bacteria; and we believe that the fundamental curing changes begin and continue during the ripening of the curd in the vat, but do not make themselves manifest till later.

8. The lactic acid bacteria in cheese, not only decrease in number with the lapse of time, but gradually lose their acid-producing power; and this circumstance, with the fact that the most rapid decline in the number of these bacilli takes place in cheese in the ordinary curing room, may give rise to a condition which is favorable to the development of any taint-producing species which may be present. Hence the cheese from a cold storage or a well regulated cool room ought to keep better than cheese from the ordinary curing room.

9. The flavor of cheese depends mainly on the breaking down of the casein under the influence of the curing agent (likely the pepsin of the rennet), aided by the acidity and other conditions produced by the growth of the lactic acid bacilli; while the most important factor in the control of these conditions is the temperature—a regular and cold or cool temperature being necessary for the best results.

10. As may be seen from the conclusions and remarks of the judges of the cheese analysed, cheese kept in cold storage at about 40 degrees Fah., and also those kept in a well-regulated cool room, were better in flavor and body and of much greater commercial value than cheese kept in the ordinary curing room with its variable and generally too high temperature.

CHEESE OF JUNE 22ND, 1899, (KINGSTON).

Date and Age.		Temperature F.			Cheese from regulated room.			Temperature F.			Cheese from variable room.		
		Max.	Min.	Av.	Lactic Acid Bact.	Gas formers.	Other Bact.	Max.	Min.	Av.	Lactic Acid Bact.	Gas formers.	Other Bact.
June 24. ...	2	65	61	62.5	628,750,000	800,000(a)	300,000(b)	74	61	°	628,750,000	800,000(a)	300,000(b)
July 4. ...	12	65	61.1	61.1	105,560,000	...	...	78	58	67	78,937,500	...	...
" 18. ...	26	64	58	61.5	98,750,000	...	...	79	60	68.5	63,125,000	...	...
Aug. 22. ...	61	65	56	62.5	15,000,000	...	...	81	56	71.6	4,500,000	...	40,000(c)
Sept. 5. ...	75	67	60	63.2	11,200,000	...	...	78	62	70.5	1,042,000	...	...
" 18. ...	88	62	49	56	1,400,000	...	...	...	...	...	...	...	...
" 25. ...	95	65	51	59	2,430,000	...	...	...	...	...	...	...	...
Oct. 3. ...	103	63	44	54	1,715,000	...	...	...	...	...	...	...	...
" 16. ...	116	64	45	55	1,650,000	...	...	...	...	...	...	...	...
Nov. 23. ...	152	...	...	50	415,000	...	...	...	...	...	...	...	...

CHEESE OF JULY 1ST, 1899, (KINGSTON).

July 4. ...	3	63	61	62	461,500,000	2,500,000(a)	1,500,000(b)	78	62	71.3	454,000,000	1,750,000(a)	1,600,000(a)
" 11. ...	10	64	58	61.7	148,120,000	...	...	79	62	72.3	128,600,000	...	...
" 25. ...	24	63	57	61	115,000,000	570,000(a)	...	77	55	68.3	44,875,000	...	...
Aug. 1. ...	31	64	58	62	78,315,000	...	...	80	58	73	49,300,000	400,000(a)	200,000(a)
" 15. ...	45	65	56	61.8	43,386,000	...	115,300(d)	79	56	63.5	16,750,000	...	...
" 30. ...	60	67	57	62.5	...	...	...	81	58	70.3	6,375,000	75,000(a)	...
Sept. 18. ...	79	66	54	58	11,020,000	...	...	...	...	...	...	...	...
" 25. ...	86	65	51	59	6,750,000	...	...	...	...	...	...	...	...
Oct. 3. ...	94	63	44	54	15,400,000	40,000(a)	...	...	...	...	...	...	...
" 16. ...	107	64	45	55	11,300,000	...	...	...	...	...	...	...	...
" 30. ...	121	65	50	55	5,800,000	...	...	...	...	...	...	...	...
Nov. 2. ...	145	...	...	50	2,030,000	...	10,000(e)	...	...	...	...	...	...

CHEESE OF JULY 7TH 1899, (KINGSTON).

July 11. ...	4	62	58	61	146,322,000	63,000(a)	504,000(e)	79	62	70.6	110,750,000	100,000(a)	375,000(e)
" 18. ...	11	63	58	61.3	48,250,000	...	100,000(e)	77	60	70.3	51,460,000	...	50,000(g)
" 25. ...	18	63	57	60.5	21,625,000	...	...	...	...	...	...	...	...
Aug. 1. ...	25	64	58	62	24,850,000	...	...	80	55	69.1	10,250,000	...	90,000(h)

" 22.	46	65	56	62	9,850,000	.....	.....	81	56	69	5,600,000	.....
Sept. 20.	75	66	49	60	460,000	.....	4,000(b)	.....	.....	.....	.....	.....
Oct. 16.	102	64	44	55	527,500	.....	5,000(g)	.....	.....	.....	.....	.....
Nov. 23.	140	.....	.....	50	525,000	.....	.....	.....	.....	.....	.....	.....

CHEESE OF JULY 13TH, 1899. (KINGSTON).

July 18.	5	63	58	61.5	385,000,000	.....	.....	77	60	70.3	30,865,400	250,000 (a)
" 25.	12	63	57	60.5	.....	.....	.....	74	55	66	27,083,000	.....
Aug. 1.	19	64	58	62	39,353,000	.....	.....	80	58	73	19,440,000	100,000 (b)
Aug. 15.	33	65	56	61.8	22,040,000	.....	80,000 (b)	79	56	68.5	22,937,500	.....
Aug. 29.	47	67	57	62.5	.....	.....	.....	81	58	70.3	5,000,000	40,000 (a)
Sept. 18.	67	66	54	58	2,510,000	.....	.....	.....	.....	.....	.....	.....
" 25.	74	65	51	59	2,880,000	.....	.....	.....	.....	.....	.....	.....
Oct. 3.	82	63	44	54	6,070,000	.....	4,000 (d)	.....	.....	.....	.....	.....
" 16.	95	64	45	55	3,256,000	.....	.....	.....	.....	.....	.....	.....
Nov. 23.	133	.....	.....	50	585,000	.....	.....	.....	.....	.....	.....	.....

CHEESE OF JULY 19TH, 1899. (KINGSTON).

July 25.	6	63	57	60.5	158,150,000	.....	1,000,000 (i)	74	55	66	108,555,000	700,000 (a)
Aug. 1.	13	64	58	62	41,500,000	.....	.....	80	58	73	89,777,000	120,000 (a)
" 15.	27	65	56	61.8	89,066,000	.....	200,000 (i)	79	56	68.5	61,500,000	.....
" 22.	34	64	57	62	86,600,000	.....	.....	81	58	70	53,000,000	100,000 (i)
" 29.	41	67	60	63.2	42,800,000	.....	20,000 (i)	78	62	70.5	23,100,000	20,000 (i)
Sept. 20.	63	66	54	58	7,500,000	.....	.....	.....	.....	.....	.....	.....
Oct. 3.	76	65	44	55	15,116,000	.....	40,000 (i)	.....	.....	.....	.....	.....
Oct. 30.	193	64	44	54	5,091,000	.....	10,000 (i)	.....	.....	.....	.....	.....
Nov. 23.	127	.....	.....	50	1,170,000	.....	.....	.....	.....	.....	.....	.....

CHEESE OF JULY 29TH, 1899. (KINGSTON).

Aug. 1.	3	63	58	61.1	348,400,000	.....	2,000,000 (j)	80	58	70.3	453,333,000	1,000,000 (j)
" 15.	17	65	56	61.8	231,800,000	.....	1,000,000 (j)	79	56	68.5	193,500,000	.....
" 22.	24	64	57	62	152,614,000	.....	.....	81	58	70	.....	.....
" 29.	31	67	60	63.2	145,000,000	.....	.....	78	62	70.5	103,000,000	.....
Sept 16.	49	66	54	58	41,000,000	.....	.....	.....	.....	.....	.....	.....

(a) *S. coli communis*(d) Partly *Sarcina lutea* and partly yeasts.(e) *Micrococcus alba*.

(f) A small bacillus—producing a yellow colony—non-liquefying, etc.

(g) Bacillus related to *Proteus* group.(b) *Sarcina lutea*.(c) *B. subtilis*.(h) Orange *Micrococcus*.

(c) A white yeast.

(f) *Torula rosea*.

Species not determined. Is not active in milk.

CHEESE OF JULY 29TH, 1899.—(Continued.)

Date and Age.		Temperature.			Cheese from regulated room.			Temperature.			Cheese from variable room.		
		Max.	Min.	Av.	Lactic Acid Bact.	Gas formers.	Other Bact.	Max.	Min.	Av.	Lactic Acid Bact.	Gas formers.	Other Bact.
	Dates of exam.												
Oct. 2....	65	65	44	55	10,000,000			°	°	°			
Oct. 16....	79	64	45	55	9,750,000								
Oct. 30....	93	65	50	55	10,890,000								
Nov. 23....	117			50	3,520,000								

CHEESE OF AUGUST 10TH, 1899 (KINGSTON).

Aug. 15....	5	65	56	62.4	536,400,000	100,000 (a)		79	56	68.6	323,250,000	200,000 (a)	
Aug. 22....	12	64	57	62				81	58	70	205,400,000		
Aug. 29....	19	67	60	63.2	125,000,000		400,000 (b)	78	62	70.5	122,300,000		200,000 (b)
Sept. 20....	41	66	54	58	14,148,000								
Oct. 2....	53	65	44	55	22,200,000								
" 30....	81	64	44	54	10,935,000								
Nov. 23....	105			50	2,780,000		50,000 (b)						

CHEESE OF JULY 5TH, 1900. (KINGSTON).

July 11....	6	64	60	62	387,500,000		1,000,000 (g)	82	61	70	202,135,000		500,000 (g)
" 20....	15	64	60	62.5	12,500,000		{ 640,000 (g) 300,000 (h)	83	62	72	73,750,000		250,000 (g)
" 26....	21	65	59	62.5	56,100,000		500,000 (g)	82	68	74	20,800,000		75,000 (g) (h)
Aug. 1....	27	64	59	62.5	36,100,000		10,000 (i)	79	60	71	19,800,000		350,000 (g)
" 8....	34	64	59	61	22,755,000			78	58	68	11,430,000		20,000 (h)
" 13....	39	65	59	62.5	23,071,600		10,000 (i)	83	62	74	6,630,000		15,000 (g)
" 20....	46	66	58	62	16,135,600			81	64	73	4,812,500		15,000 (h)
Sept. 4....	61	65	56	61	4,935,000		90,000 (h)	82	60	70	3,500,000		108,000 (h)

CHEESE OF JULY 6TH, 1900 (KINGSTON).

July 11.....	5	64	60	62	300,000,000	2,600,000	{ 240,000(g) 240,000(h) 400,000(g)	82	61	70	181,800,000	1,200,000	.....
" 20.....	14	64	60	62.5	164,166,000	1,200,000	.....	83	62	72	70,568,000	240,000	60,000(g)
" 26.....	20	65	59	62.5	144,762,000	100,000	.....	82	68	74	78,154,000	408,000	200,000(i)
Aug. 1.....	26	64	59	62.5	84,300,000	.....	.....	79	60	71	36,250,000	.....	.....
" 8.....	33	64	59	61	68,520,000	.....	125,000(g)	78	58	68	33,127,500	.....	20,000(j)
" 13.....	38	65	59	62.5	40,365,000	.....	{ 125,000(g) 125,000(h)	83	62	74	15,400,000	.....	10,000(k)
" 20.....	45	66	58	62	22,105,000	.....	220,000(g)	81	64	73	2,380,000	.....	5,000(i)
" 27.....	52	65	59	62	4,520,000	.....	.....	82	60	70	1,100,000	.....	.....

CHEESE OF JULY 7TH, 1900 (KINGSTON).

July 11.....	4	64	60	62	242,200,000	.....	{ 1,360,000(g) 112,000(h)	82	61	71	236,250,000	.....	.....
" 20.....	13	64	60	62.5	197,500,000	.....	.....	83	62	72	64,881,000	.....	900,000(g)
" 26.....	19	65	59	62.5	66,364,000	.....	360,000(g)	82	68	74	52,600,000	.....	200,000(h)
Aug. 1.....	25	64	59	62.5	69,560,000	160,000	320,000(g)	79	60	71	21,400,000	.....	200,000(g)
" 8.....	32	64	59	61	70,300,000	.....	50,000	78	58	68	9,600,000	.....	200,000(h)
" 13.....	37	65	59	62.5	42,500,000	.....	30,000(k)	83	62	74	5,700,000	.....	{ 100,000(g) 50,000
" 20.....	44	66	58	62	41,700,000	.....	25,000(k)	81	64	73	4,942,000	.....	.....
Sept. 4.....	59	65	56	61	11,827,000	.....	.....	82	60	70	2,200,000	.....	20,000(g)

CHEESE OF JULY 18TH, 1900. VAT 1.

July 26.....	8	65	59	62.5	337,750,000	.....	.....	82	68	74	161,917,000	.....	.....
Aug. 1.....	14	64	59	62.5	244,800,000	.....	.....	79	60	71	115,200,000	.....	.....
" 8.....	21	64	59	61	.....	.....	.....	78	58	68	101,800,000	.....	.....
" 13.....	26	65	59	62.5	107,400,000	.....	.....	83	62	74	45,333,000	.....	.....
" 20.....	33	66	58	62	62,000,000	.....	.....	81	64	73	17,752,000	.....	.....
Sept. 4.....	48	65	56	61	14,226,000	.....	.....	82	60	70	4,225,000	.....	.....

(a) *B. coli communis*.(b) *Sarcina lutea*.(g) *A. bacillus*, non-liquefying, producing a light yellow pigment. (h) *B. fluorescens liquefaciens*. (i) *Torula alba*.(j) *B. megatherium*. (k) *A. liquefying streptococcus*. * The bacteria apart from the Lactic acid bacteria were not calculated.

CHEESE OF JULY 18TH. VAT. 3.

Date and Age.		Temperature.			Kept in regulated room.			Temperature.			Kept in ordinary room.		
		Max.	Min.	Aver.	Lactic acid Bact.	Gas formers.	Other Bact.	Max.	Min.	Aver.	Lactic acid Bact.	Gas formers.	Other Bact.
	Age.												
July 26....	8	65	59	62.5	161,430,000	.....	.....	82	68	74	344,375,000	.....	.....
Aug. 1.....	14	64	59	62.5	.....	.....	.....	79	60	71	210,000,000	.....	.....
" 8.....	21	64	59	61	331,250,000	.....	.....	78	58	68	62,000,000	.....	.....
" 13.....	26	65	59	62.5	173,000,000	.....	.....	83	62	74	48,420,000	.....	.....
" 20.....	33	66	58	62	92,300,000	.....	.....	81	64	73	.....	.....	.....
Sept. 4.....	48	65	56	61	40,950,000	.....	.....	82	60	70	12,420,000	.....	.....

CHEESE OF JULY 19TH, VAT 1. (KINGSTON).

July 26....	7	65	59	62.5	331,665,000	.....	.....	82	68	74	290,000,000	.....	.....
Aug. 1.....	13	64	59	62.5	198,000,000	.....	.....	79	60	71	226,000,000	.....	.....
" 8.....	20	64	59	61	89,773,000	.....	.....	78	58	68	156,750,000	.....	.....
" 13.....	25	65	59	62.5	35,000,000	.....	.....	83	62	74	26,563,500	.....	.....
" 20.....	32	66	58	62	69,000,000	.....	.....	81	64	73	7,725,000	.....	.....
Sept. 1.....	43	65	58	61	17,520,000	.....	.....	82	60	70	2,781,000	.....	.....

CHEESE OF JULY 1ST, 1900.

July 26....	7	65	59	62.5	344,950,000	.....	.....	82	68	74	382,750,000	.....	.....
Aug. 1.....	13	64	59	62.5	90,450,000	.....	.....	79	60	71	228,365,000	.....	.....
" 8.....	20	64	59	61	110,625,000	.....	.....	78	58	68	73,145,000	.....	.....
" 13.....	25	65	59	62.5	125,000,000	.....	.....	83	62	74	22,550,000	.....	.....
" 20.....	32	66	58	62	57,500,000	.....	.....	81	64	73	11,775,000	.....	.....
Sept. 1.....	43	65	58	61	18,057,142	.....	.....	82	60	70	3,750,000	.....	.....

CHEESE OF APRIL 26,—A. REFRIGERATOR. (GUELPH).

Date.	Age.	Temperature.			Lactic acid Bact.	Gas formers.	Digestors.	Other Bact.
		Max.	Min.	Av.				
		°	°	°				
April 26	1	38	35	36.5	543,000,000	.....	.....	.....
May 13.....	17	38	36	37	566,000,000	.....	.....	130,000
" 21.....	25	38	36	37	547,650,000	.....	.....	238,000
" 28.....	32	38	38	37	448,700,000	.....	.....	270,000
June 6	41	39	37	38	554,300,000	.....	.....	120,000
" 13	48	40	37	38.5	477,000,000	.....	.....	.....
" 22	57	42	38	40	155,500,000	.....	.....	.....
July 16.....	81	42	39	40.5	44,500,000	.....	.....	.....
Aug. 5.....	101	42	38	40	44,250,000	.....	.....	.....

CHEESE OF APRIL 26TH,—B. ONE WEEK IN ORDINARY CURING ROOM AND THEN INTO REFRIGERATOR.

April 26	1	65	55	60	543,000,000	.....	.....	.....
May 6.....	10	65	55	60	390,000,000	.....	2,000,000(g)	.....
" 28.....	32	38	38	38	123,800,000	.....	400,000(g)	.....
June 6.....	41	39	37	38	166,800,000	.....	.....	.....
" 13.....	48	40	37	38.5	117,300,000	.....	.....	.....
" 22.....	57	42	38	40	27,200,000	.....	.....	.....

CHEESE OF APRIL 26TH,—C. TWO WEEKS IN ORDINARY CURING ROOM AND THEN INTO REFRIGERATOR.

April 26.....	1	65	55	60	543,000,000	.....	.....	.....
May 11.....	16	65	55	60	146,500,000	.....	310,000(g)	.....
" 28.....	32	38	38	38	123,700,000	.....	70,000(g)	.....
June 6	41	39	37	38	124,200,000	.....	.....	.....
" 13.....	48	40	37	38.5	74,000,000	.....	.....	.....
" 22.....	57	42	38	40	32,000,000	.....	.....	.....

CHEESE OF APRIL 26TH,—E. ORDINARY CURING ROOM.

April 26.....	1	65	55	60	543,000,000	.....	.....	.....
May 28.....	32	70	65	63	122,000,000	.....	400,000(g)	.....
June 6	41	70	62	66	28,250,000	.....	105,000(g)	.....
" 13.....	48	73	58	64	26,000,000	.....	72,000(g)	.....
" 22.....	57	74	58	67	9,234,000	.....	.....	.....
July 16.....	81	80	68	75	3,430,000	.....	.....	.....

CHEESE OF APRIL 29TH,—A. REFRIGERATOR. (GUELPH).

May 2	3	38	37	37.5	486,000,000	582,000(a)	194,000(b)	1,500,000
" 21.....	22	38	36	37	541,000,000	210,000(a)	.....	630,000
" 28.....	29	38	38	38	519,000,000	.....	.....	.....
June 6.....	38	39	37	38	482,000,000	.....	.....	182,000
" 12.....	44	40	37	38.5	310,000,000	.....	91,000(b)	.....
" 22.....	54	42	38	40	261,000,000	.....	.....	.....
July 16.....	78	42	39	40.5	73,800,000	.....	.....	.....
Aug. 7.	100	42	38	40	42,300,000	.....	.....	.....

(a) *B. lactis aerogenes*. (b) Partly *M. aureus lactis*. (g) *B. subtilis* group.

CHEESE OF APRIL 29TH,—B. ONE WEEK IN ORDINARY CURING ROOM AND THEN INTO REFRIGERATOR.

Date.	Age.	Temperature.			Lactic acid Bact.	Gas formers.	Digestors.	Other Bact.
		Max.	Min.	Av.				
May 2...	3	65°	55°	60°	486,000,000	582,000(a)	194,000(b)	1,500,000
" 7...	8	65	55	60	169,000,000	.....	132,000(b)	760,000
" 28...	29	38	38	38	138,000,000	.....	.....	186,200
June 6...	38	39	37	38	106,800,000	.....	.....	.....
" 13...	45	40	37	38.5	93,800,000	.....	126,000(b)	.....
" 22...	54	42	38	40	88,150,000	.....	.....	.....

CHEESE OF APRIL 29TH,—C. TWO WEEKS IN ORDINARY CURING ROOM AND THEN INTO REFRIGERATOR.

May 2...	3	65	55	60	486,000,000	582,000(a)	194,000(b)	1,500,000
" 14...	15	66	55	61	117,600,000	.....	.....	.....
" 28...	29	38	38	38	77,700,000	.....	.....	.....
June 6...	38	39	37	38	75,500,000	.....	.....	.....
" 13...	45	40	37	38.5	57,000,000	.....	.....	.....
" 22...	54	42	38	40	54,000,000	.....	.....	.....

CHEESE OF APRIL 29TH,—D. THREE WEEKS IN ORDINARY CURING ROOM AND THEN INTO REFRIGERATOR.

May 2...	3	65	55	60	486,000,000	582,000(a)	194,000(b)	1,500,000
" 21...	22	70	55	63	129,000,000	.....	.....	.....
" 28...	29	38	38	38	120,100,000	.....	.....	.....
June 6...	38	39	37	38	119,600,000	.....	.....	.....
" 13...	45	40	37	38.5	35,000,000	.....	.....	.....
" 22...	54	42	38	40	30,500,000	.....	.....	.....

CHEESE OF APRIL 29TH,—E. ORDINARY CURING ROOM.

May 2...	3	65	55	60	486,000,000	582,000(a)	194,000(b)	1,500,000
June 6...	38	70	62	66	45,000,000	119,000(a)	.....	.....
" 13...	45	73	58	64	39,700,000	.....	.....	.....
" 22...	54	74	58	67	5,300,000	.....	.....	.....
July 16...	78	80	68	75	2,750,000	.....	.....	.....

CHEESE OF MAY 6TH,—A. REFRIGERATOR. (GUELPH.)

May 6...	1	39	37	38	523,000,000	1,000,000(a)	.....	500,000
" 21...	15	38	36	37	489,000,000	500,000(a)	.....	.....
" 29...	23	38	38	38	482,000,000	.....	.....	.....
June 4...	29	39	37	38	475,000,000	.....	.....	.....
" 19...	44	42	38	40	397,000,000	.....	.....	.....
" 29...	54	42	38	40	471,000,000	.....	.....	.....
July 16...	71	42	39	40.5	473,000,000	.....	.....	.....
Aug. 7...	93	42	38	40	437,000,000	.....	.....	.....

(a) *B. lactis aërogenes*. (b) Partly *M. aureus lactis*.

CHEESE OF MAY 6TH,—B. ONE WEEK IN ORDINARY CURING ROOM AND THEN INTO REFRIGERATOR.

Date.	Age.	Temperature.			Lactic Acid Bact.	Gas formers.	Digestors.	Other Bact.
		Max.	Min.	Av.				
May 6...	1	64	56	60	523,000,000	1,000,000(a)	.....	500,000
" 14...	8	65	55	60	263,000,000	750,000(a)	.....	.....
" 29...	23	38	38	38	274,000,000	.....	.....	.....
June 4...	29	39	37	38	255,100,000	.....	.....	.....
" 12...	37	40	37	38.5	200,200,000	.....	.....	.....
" 20...	45	42	38	40	118,000,000	.....	.....	.....
" 29...	54	42	38	40	110,000,000	.....	.....	.....

CHEESE OF MAY 6TH,—C. TWO WEEKS IN ORDINARY CURING ROOM AND THEN INTO REFRIGERATOR.

May 6...	1	64	56	60	523,000,000	1,000,000(a)	.....	500,000
" 21...	15	70	55	63	145,000,000	.....	.....	.....
" 29...	23	38	38	38	152,000,000	.....	.....	.....
June 4...	29	39	37	38	141,500,000	.....	.....	.....
" 12...	37	40	37	38.5	128,700,000	.....	.....	.....
" 29...	54	42	38	40	109,000,000	.....	.....	.....

CHEESE OF MAY 6TH,—D. THREE WEEKS IN ORDINARY CURING ROOM AND THEN INTO REFRIGERATOR.

May 6...	1	64	56	60	523,000,000	1,000,000(a)	.....	500,000
" 14...	8	65	55	60	263,000,000	750,000(a)	.....	.....
" 21...	15	70	55	63	145,000,000	.....	.....	.....
" 29...	23	69	58	64	195,000,000	.....	.....	.....
June 4...	29	39	37	38	161,000,000	.....	.....	.....
" 12...	37	40	37	38.5	102,000,000	.....	.....	.....
" 20...	45	42	38	40	104,500,000	.....	.....	.....
" 29...	54	42	38	40	72,500,000	.....	.....	.....

CHEESE OF MAY 6TH,—E. ORDINARY CURING ROOM.

May 6...	1	64	56	60	523,000,000	1,000,000(a)	.....	500,000
" 14...	8	65	55	60	263,000,000	750,000(a)	.....	.....
" 21...	15	70	55	63	145,000,000	560,000(a)	.....	.....
" 29...	23	69	58	64	.....	.....	.....	.....
June 4...	29	70	62	66	97,000,000	.....	.....	.....
" 12...	37	73	58	64	82,600,000	.....	.....	.....
" 20...	45	74	58	67	37,000,000	.....	.....	.....
" 29...	54	68	57	64	12,000,000	.....	.....	.....
July 16...	71	80	68	75	4,100,000	.....	.....	.....

(a) *B. lactis aërogenes*.

CHEESE OF MAY 13TH,—REFRIGERATOR. (GUELPH).

Date.	Age.	Temperature.			Lactic Acid Bact.	Gas formers.	Digestors.	Other Bact.
		Max.	Min.	Av.				
May 13..	1	38	36	37	623,000,000	1,200,000(a)	2,400,000(d)(g)	1,200,000
" 21..	8	38	36	37	612,000,000	800,000(a)	1,600,000(d)(g)	.....
" 29..	16	38	38	38	615,000,000	.....	710,000(d)(g)	.....
June 6..	24	39	37	38	596,600,000	450,000(a)	900,000(d)(g)	.....
" 12..	30	40	37	38.5	561,500,000	.....	.....	.....
" 21..	39	42	38	40	461,000,000	.....	.....	.....
" 24..	42	42	38	40	360,000,000	.....	.....	.....
July 16..	64	42	39	40.5	431,000,000	.....	.....	.....
Aug. 7..	86	42	38	40	358,000,000	.....	.....	.....

CHEESE OF MAY 13TH,—B. ONE WEEK IN ORDINARY CURING ROOM AND THEN INTO REFRIGERATOR.

May 13..	1	65	55	60	623,000,000	1,200,000(a)	2,400,000(d)(g)	1,200,000
" 21..	8	70	55	63	290,000,000	400,000(a)	800,000(d)(g)	800,000
" 29..	16	38	38	38	162,000,000	.....	.....	.....
June 5..	23	39	37	38	135,000,000	270,000(a)	.....	.....
" 12..	30	40	37	38.5	147,000,000	.....	.....	.....
" 21..	39	42	38	40	209,000,000	.....	.....	.....
" 28..	46	42	38	40	171,000,000	.....	.....	.....

CHEESE OF MAY 13TH,—C. TWO WEEKS IN ORDINARY CURING ROOM AND THEN INTO REFRIGERATOR.

May 13..	1	65	55	60	623,000,000	1,200,000(a)	2,400,000(d)(g)	1,200,000
" 21..	8	70	55	63	290,000,000	400,000(a)	800,000(d)(g)	800,000
" 29..	16	69	58	64	229,000,000	.....	220,000(d)(g)	.....
June 5..	23	39	37	38	155,000,000	175,000(a)	.....	.....
" 12..	30	40	37	38.5	162,000,000	.....	.....	.....
" 21..	39	42	38	40	137,000,000	.....	.....	.....
" 28..	46	42	38	40	133,000,000	.....	.....	.....

CHEESE OF MAY 13TH,—D. THREE WEEKS IN ORDINARY CURING ROOM AND THEN INTO REFRIGERATOR.

May 13..	1	65	55	60	623,000,000	1,200,000(a)	2,400,000(d)(g)	1,200,000
" 21..	8	70	55	63	290,000,000	400,000(a)	800,000(d)(g)	800,000
" 29..	16	69	58	64	229,000,000	.....	200,000(d)(g)	.....
June 4..	22	70	62	66	94,000,000	145,000(a)	.....	.....
" 12..	30	40	37	38.5	104,000,000	.....	.....	.....
" 21..	39	42	38	40	106,000,000	.....	.....	.....
" 28..	46	42	38	40	87,000,000	.....	.....	.....

CHEESE OF MAY 13TH,—E. IN ORDINARY CURING ROOM.

May 13..	1	65	55	60	623,000,000	1,200,000(a)	2,400,000(d)(g)	1,200,000
" 21..	8	70	55	63	290,000,000	400,000(a)	800,000(d)(g)	800,000
" 29..	16	69	58	64	229,000,000	.....	220,000(d)(g)	.....
June 4..	22	70	62	66	154,000,000	175,000(a)	.....	.....
" 11..	29	73	58	64	90,000,000	90,000(a)	.....	.....
" 21..	39	74	58	67	86,000,000	.....	.....	.....
" 29..	47	68	57	64	24,000,000	.....	.....	.....
July 16..	64	80	68	75	17,000,000	.....	.....	.....

(a) *B. lactis aerogenes*. (d) *M. varians lactis*. (g) *B. subtilis*.

CHEESE OF MAY 20TH,—A. REFRIGERATOR. (GUELPH).

Date.	Age.	Temperature.			Lactic Acid Bact.	Gas formers.	Digestors.	Other Bact.
		Max.	Min.	Av.				
May 20...	1	38	36	37	500,000,000	1,000,000(c)	95,000(e)	.....
" 28...	8	38	38	38	473,000,000	.....	.....	.....
June 4...	15	39	37	38	490,000,000	.....	.....	.....
" 11...	22	40	37	38.5	446,000,000	125,000(e)	.....	.....
" 18...	29	42	38	40	496,000,000	.....	.....	.....
" 27...	38	42	38	40	491,000,000	.....	.....	.....
July 18...	59	42	39	40.5	445,000,000	.....	.....	.....
Aug. 7...	79	42	38	40	431,000,000	.....	.....	.....

CHEESE OF MAY 20TH,—B. ONE WEEK IN ORDINARY CURING ROOM AND THEN INTO REFRIGERATOR.

May 20...	1	70	55	63	500,000,000	1,000,000(c)	98,000(e)(d)	.....
" 28...	8	69	58	64	456,000,000	620,000(c)	310,000(e)(d)	.....
June 4...	15	39	37	38	455,000,000	.....	.....	.....
" 11...	22	40	37	38.5	350,000,000	123,000(e)	.....	.....
" 18...	29	42	38	40	378,000,000	.....	.....	.....
" 28...	39	42	38	40	296,000,000	.....	.....	.....

CHEESE OF MAY 20TH,—C. TWO WEEKS IN ORDINARY CURING ROOM AND THEN INTO REFRIGERATOR.

May 20...	1	70	55	63	500,000,000	1,000,000(c)	95,000(e)	.....
" 28...	8	69	58	64	456,000,000	620,000	310,000(e)(d)	.....
June 4...	15	70	62	66	329,000,000	200,000	.....	.....
" 11...	22	40	37	38.5	313,000,000	.....	.....	.....
" 19...	30	42	38	40	289,000,000	.....	.....	.....
" 29...	40	42	38	40	216,000,000	.....	.....	.....

CHEESE OF MAY 20TH,—D. THREE WEEKS IN ORDINARY CURING ROOM AND THEN INTO REFRIGERATOR.

May 20...	1	70	55	63	500,000,000	1,000,000(c)	95,000(e)	.....
" 28...	8	69	58	64	456,000,000	620,000(c)	310,000(e)(d)	.....
June 4...	15	70	62	66	320,000,000	200,000(c)	.....	.....
" 11...	22	73	58	64	172,000,000	.....	.....	.....
" 19...	30	42	38	40	139,000,000	.....	.....	.....
" 29...	40	42	38	40	116,000,000	.....	.....	.....

CHEESE OF MAY 20TH,—E. ORDINARY CURING ROOM.

May 20...	1	70	55	63	500,000,000	1,000,000(c)	95,000(c)	.....
" 28...	8	69	58	64	337,000,000	.....	.....	.....
June 18...	29	74	58	67	123,000,000	210,000(c)	.....	.....
" 29...	40	68	57	64	41,000,000	.....	82,000(d)	.....
July 9...	50	80	68	74	3,000,000	.....	.....	.....

(c) *B. coli* and *B. lactis aërogenes*. (d) *M. varians lactis*. (e) *B. fulvus*.

CHEESE OF MAY 27TH,—A. REFRIGERATOR (GUELPH).

Date.	Age	Temperature.			Lactic Acid Bact.	Gas formers.	Digestors.	Other Bact.
		Min.	Max.	Av.				
		c	o	o				
May 27...	1	38	38	38	635,000,000	.....	.....	.....
June 4...	8	39	37	38	520,000,000	.....	.....	.....
" 11...	15	40	37	38.5	475,000,000	.....	.....	.....
" 18...	22	42	38	40	477,000,000	.....	.....	.....
" 25...	29	42	38	40	494,000,000	.....	.....	.....
July 18...	52	42	39	40.5	253,000,000	.....	.....	.....
Aug. 7...	72	42	38	40	255,000,000	.....	.....	.....

CHEESE OF MAY 27TH,—E. ORDINARY CURING ROOM.

May 27...	1	69	58	64	635,000,000	.....	.....	.....
June 4...	8	70	62	66	273,000,000	.....	.....	.....
" 11...	15	73	58	64	264,000,000	.....	.....	.....
" 25...	29	74	58	67	175,000,000	.....	.....	.....
Aug. 7...	72	71	62	67	32,000,000	.....	.....	.....

CHEESE OF JUNE 3RD,—A. REFRIGERATOR (GUELPH).

June 3...	1	39	37	38	584,000,000	7,000,000(c)	800,000(g)	.....
" 11...	8	40	37	38.5	494,000,000	2,000,000(c)	.....	.....
" 18...	15	42	68	40	366,000,000	420,000(c)	.....	.....
" 24...	21	42	88	40	308,000,000	114,000(c)	.....	.....
July 15...	45	42	39	40.5	302,000,000	.....	.....	.....

CHEESE OF JUNE 3RD,—E. ORDINARY CURING ROOM.

June 3...	1	70	62	66	584,000,000	7,000,000(c)	800,000(g)	.....
" 11...	8	73	58	64	341,000,000	1,630,000(c)	.....	.....
" 18...	15	74	58	67	291,000,000	1,212,000(c)	.....	.....
" 24...	21	74	58	67	209,000,000	80,000(c)	.....	.....
July 15...	45	80	68	75	161,000,000	523,000(c)	.....	.....
" 25...	55	77	61	69	87,000,000	.....	.....	.....
Aug. 9...	70	71	62	67	4,200,000	.....	.....	.....

(c) *B. coli* and *B. lactis aërogenes*.(g) *B. subtilis* and *B. halofaciens*.

Ontario Agricultural College and Experimental Farm.

RIPENING OF CHEESE IN COLD STORAGE.

By Prof. H. H. Dean, B.S.A., and Prof. R. Marcourt, B.S.A.

The following results have been obtained in continuing the experiments relating to the ripening of cheese in cold storage. Bulletin No. 121, published in June, 1902, gave the results of experiments conducted in 1901, which were reported as preliminary. The experiments of 1902 are a continuation and extension of the work.

Possibly no phase of the cheese industry has received so much attention in recent years, as the ripening of cheese at low temperatures. The season of 1902 was phenomenally cool, and Canadian cheese never enjoyed so good a reputation in British markets, as they did last season. This was partly due to the scarcity of cheese, but the cool season, no doubt, had a great deal to do with it; thus was demonstrated in a very forcible way the great value of low temperatures in the manufacture and transportation of Canadian cheese.

NATURE OF THE EXPERIMENTS.

The experiments of 1902 were divided into eight series or groups as follows:

1. Four cheese, marked A, B, C and E, weighing about thirty pounds each, were made from one vat of milk. A was placed, directly from the press, in an ice cold storage, which had an average temperature of 38.9. The lowest average monthly temperature was 37 degrees in April, the highest was 40.5 degrees in August. B was placed in an ordinary ripening room, which had an average temperature of 62 degrees, for one week, when it was moved to the ice cold storage. The highest monthly average of this ripening room was 66.2 degrees in July and the lowest 58.2 degrees in October. C was also placed in the ordinary ripening room and moved to the cold storage room at the end of two weeks. E was allowed to remain in the ripening room all the time. (The D cheese, which was moved to the cold storage at the end of three weeks in the experiments of 1901, was dropped from the tests in 1902.)

2. Five cheese, weighing about 30 pounds each, were made from one vat of milk and marked A, B, C, D, and E. The first four were placed at once, after taking them from the press, into an ice cold storage, while the fifth (E) was put in the ordinary ripening room, and remained there all the time. The A cheese remained in the cold storage during all the time of the experiments. B was moved to the ordinary ripening room, which had an average temperature of 62 degrees, at the end of one month. C was moved from the cold storage at the end of two months, and D at the end of three months.

The object of this experiment was to see what effect the changing of cheese, from a cold storage to an ordinary cool temperature, would have on the quality of the cheese.

3. The third series related to the effect on cheese of using an extra quantity of rennet (6 ounces per 1,000 pounds milk) in the milk as compared with the regular quantity of three and a third ounces per 1,000 pounds milk. The A cheese were placed directly in cold storage, the E in an ordinary ripening room,

while the B and C were moved from the ripening room to cold storage at the end of one and two weeks respectively, as in series 1.

4. Series 4 consisted of two sets of experiments. In both cases the cheese were made by using a large quantity of rennet (6 ounces per 1,000 pounds milk) cooking to 94 degrees instead of 98 degrees, and using one-half pound less (two pounds instead of two and one-half) salt per 100 pounds curd. One-half the cheese were ripened in an ordinary ripening room and the other half in an ice cold storage.

5. In the fifth series the curds were salted at the rate of two and a quarter pounds salt per 100 pounds curd as compared with two and three-quarter pounds salt per 100 pounds curd. Both lots were ripened in cold storage.

6. Five cheese, marked A, B, C, D, E, were made from one vat of milk. A and B were taken from the press to cold storage. A was put on a shelf and turned regularly, while B was placed in a cheese box and not turned. C, D, and E were put in the ripening room where E remained, but C and D were moved to the cold storage at the end of one week. C was placed on a shelf and turned regularly, while D was put in a cheese box and not turned.

7. This series related to the effect of formalin sprayed on the cheese and in the box to prevent mould.

8. Cheese were dipped in melted paraffine wax, which was at a temperature of about 180 degrees. Some of the cheese were placed in cold storage and some in an ordinary ripening room. A portion were dipped in the wax directly from the press, some at the end of one week, some at the end of two weeks and some at the end of three weeks, and the remainder were not coated with the paraffine.

RESULTS OF THE EXPERIMENTS.

1. Cheese Ripened in Cold Storage and the Ordinary Ripening Room.

From April 14th to September 15th, 1902, six lots of cheese were made—24 cheese in all. Six of these (the A's) were placed directly into cold storage from the press. The remaining eighteen were placed in the ripening room, six of which (B's) were removed to the cold storage at the end of a week, another six (C's) were moved into the cold storage at the end of two weeks, while the remaining six (E's) were allowed to ripen in the ordinary room.

The A cheese lost an average of 2.26 per cent. in weight at the end of one month. The B cheese lost an average of 2.90 per cent. in the same time. The C lost 3.20 per cent., and the E cheese 4.21 per cent. in weight at the end of one month.

The cheese were all scored from one to four times. The first scoring of the E cheese was made in from six weeks to two months after they were made, while the cheese placed in cold storage were scored the first time when about three months old, and again at intervals of one month. This plan was followed in the scoring of all the cheese in the cold storage experiments.

Average Score of the Cheese. (All cheese were scored 10 for finish.)

Qualities.	Max.	A.	B.	C.	E.
Flavor	40	35.77	36.34	36.15	32.18
Closeness	15	14.16	13.93	13.84	13.65
Even Color	15	14.56	14.61	14.61	13.75
Texture	20	17.96	18.00	18.00	16.00
Finish.	10	10.00	10.00	10.00	10.00
Total	100	92.45	92.88	92.60	85.58

It will be noticed that there is very little difference in the quality of the cheese, whether put directly into cold storage or placed there after one or two weeks in an ordinary ripening room. However, we need to bear in mind that 1902 was an exceptionally cool season, and the cheese held in the regular ripening room for two weeks did not deteriorate so much as they would likely do in a hot summer. In 1901 those cheese put directly into cold storage from the press stood first in quality. If it is more convenient to do so we should judge that placing cheese in cold storage once a week, from the factory ripening (curing) room would be quite satisfactory.

The E cheese ripened in the ordinary room were inferior in quality as compared with those in cold storage. These results agree with those obtained in 1901.

2. Cheese moved from Cold Storage to Ripening Room.

It has been claimed that if dairy goods are held for some time in cold storage, and then brought into a moderately warm temperature, they would deteriorate very rapidly. To test this point, from April 17th to November 12th, six lots of cheese were made, having five cheese in each lot—thirty cheese altogether. Four cheese in each lot were taken to the cold storage from the press, while the fifth was placed in an ordinary room and remained there. One of the four (A) remained in the cold storage, while the other three were taken to the ripening room—B at the end of one month, C in two months, and D in three months.

The A cheese which remained in the cold storage lost 2.04 per cent. in weight at the end of a month, the B cheese lost 2.18 per cent., the C cheese 2.18, the D 1.87, and the E, in the ordinary ripening room lost 4.24 per cent. in weight in one month.

Average Score of the Cheese. (All cheese scored ten for finish.)

Qualities.	Max.	A.	B.	C.	D.	E.
Flavor..	40	36.80	35.46	36.04	36.39	33.69
Closeness..	15	14.36	13.88	13.83	13.72	13.80
Even Color..	15	14.56	14.46	14.45	14.83	13.80
Texture.....	20	18.00	17.15	17.29	17.59	16.30
Finish..	10	10.00	10.00	10.00	10.00	10.00
Total.....	100	93.72	90.95	91.61	92.53	87.59

The cheese were scored about once a month during the season, after they became ripe enough to judge of their quality. The final scorings were made in April, 1903, hence there has been every opportunity to judge of the effects of moving cheese from cold storage to ordinary temperatures. The scorings show that the A cheese, which remained in the cold storage during the whole ripening period were first in quality, and the cheese range in order of merit from the date of moving them—the best cheese being those which remained in cold storage longest, although there was no marked deterioration in those moved to a warmer temperature. All the cheese which were ripened in cold storage from one to three months were better in quality than those in the ordinary room.

3. Cheese Made with Extra Rennet and Ripened in Cold Storage.

Eight lots of cheese, having four in each lot, were made between April 21st and September 8th. Each lot was made by using rennet at the rate of six ounces per 1,000 pounds milk instead of the usual quantity (three and a third ounces).

The A cheese were placed directly from the press in cold storage at an average temperature of 38.9 degrees. The B and C cheese were moved into cold storage at the end of one week and two weeks, while E remained in the ordinary room.

The percentage loss in weight in one month was respectively 2.37, 2.75, 3.20, and 3.86, on cheese weighing about 30 pounds each.

The average score of the cheese was as follows:

Average Score of the Cheese.

Qualities.	Max.	A.	B.	C.	E.
Flavor.....	40	36.70	26.70	36.20	33.30
Closeness.....	15	14.30	14.25	13.85	13.50
Even Color.....	15	14.80	14.67	14.60	14.60
Texture.....	20	18.65	18.27	18.10	17.70
Finish.....	10	10.00	10.00	10.00	10.00
Total.....	100	94.45	93.89	92.75	89.10

The scorings show that the cheese placed directly in cold storage were best in quality, and the other two lots range in quality according to the time of placing in cold storage—those put in at the end of a week being first and those at the end of two weeks being second, while those ripened in the ordinary room are poorest. In series one there was very little difference in the first three lots whether placed at once into cold storage, or whether placed at the end of one or two weeks. In this series with the larger quantity of rennet, those placed directly into cold storage scored considerably higher, and they are also higher in scoring than the average of either series 1 or 2.

4. Cheese Made with Extra Rennet, Cooked to 94 Degrees and Salted Lightly.

Twelve lots of cheese were made from May 20th to August 21st from milk containing an average of 3.71 per cent. fat. One-half the cheese were made in the usual way, and the other half were made by using from two and a half to six ounces of rennet per 1,000 pounds milk; the curds were cooked to 94 degrees, and they were salted one-half pound of salt less per 100 pounds curd. Both lots were ripened in an ordinary ripening room at an average temperature of 62 degrees, and a humidity of 80.2 per cent.

The other set of experiments belonging to this series, consisted of fourteen lots of cheese made between April 22nd and August 15th from milk averaging 3.73 per cent. of fat. They were made similar to the first set, i.e., one-half in the usual way and the other half by using more rennet, cooking at 94 degrees and using one-half pound less salt, but both lots were ripened in cold storage at an average temperature of 38.9 degrees, and 90 per cent. humidity.

Average Score of Cheese in Series 4.

Qualities.	Max.	Ripened in ordinary room.		Ripened in cold storage.	
		Cheese made with extra rennet, etc.	Cheese made in ordinary way.	Cheese made with extra rennet, etc.	Cheese made in ordinary way.
Flavor	40	34.50	34.50	35.76	36.29
Closeness	15	13.66	13.50	14.17	14.23
Even color	15	13.82	13.82	14.47	14.58
Texture	20	16.66	16.66	17.00	17.88
Finish	10	10.00	10.00	10.00	10.00
Total	100	88.64	88.48	91.40	92.98

The green cheese made by using an extra amount of rennet, cooking to a lower temperature and using less salt, produced an increase of 1.1 per cent. of ripened cheese when ripened in the ordinary room, and an increase of 2.4 per cent. when ripened in cold storage. The scorings show very little difference in the average quality of the cheese ripened in the ordinary room, which is different from the results obtained in previous years when such cheese were "acidic" and of inferior quality. The cool season may account for the difference in the results for 1902.

The other lots of cheese made from extra rennet, etc., and those made in the usual way, but ripened in the cold storage, were both superior in quality as shown by the scorings. However, the cheese made in the usual way scored somewhat higher, and we are not prepared to recommend cheesemakers to leave more moisture in the curds to increase the yield of cheese ripened in cold storage, until we have further data. It is quite possible to increase the yield of cheese from one to two and a half per cent., but it would appear to be at the expense of quality, so far as we have light at present.

Further experiments made in 1903 indicate that the quality of the cheese was not injured by an increase of one to two per cent. moisture in the cheese ripened in mechanical cold storage, though it might be injured in an ice cold storage.

5. Ordinary vs. Light-Salted Cheese Ripened in Cold Storage.

In series 5 the object was to note the effect of using one-half pound less salt per 100 pounds curd, when cheese were ripened in cold storage. Between August 16th and October 11th, 1902, twelve lots of cheese were made. At the time of salting, the curds were equally divided, and six were salted at the rate of two and a quarter pounds of salt per 100 pounds curd, while the other six lots were salted at the rate of two and three-quarter pounds salt per 100 pounds curd. The cheese were made from milk averaging 3.85 per cent. fat, and averaged about 31 pounds in weight. There was a slight increase (about one-half a pound on 31 pounds. cheese) in the yield of the cheese by salting two and a quarter pounds per 100 pounds curd. The average total score was 93.78 for the cheese lightly salted and 94.46 for those salted in the usual way. There was a slight decrease in the yield of the cheese by the heavier salting, and an improvement in the quality.

6. Boxing Green Cheese and Ripening in Cold Storage.

This series was undertaken to obtain further data upon the practicability of placing cheese in a box directly from the press, or after remaining one week in an ordinary ripening room, instead of placing the cheese on shelves and turning them daily, which involves a great deal of labor.

Between July 2nd and November 5th, 1902, twenty-five cheese were made. Five were marked A, and were put directly from the press on a shelf in the cold storage and turned frequently. Five were marked B and also taken directly from the press to cold storage, but were put into boxes without turning. C and D were taken to the cold storage, after remaining a week in the ordinary ripening room, when the C's were placed on a shelf and turned, while the D's were put into a box and not turned. The E's remained in the ordinary ripening room.

The A's lost an average of 2.35 per cent. in weight during one month, while ripening, the B's 1.74, the C's 2.69, the D's 2.36 and the E's 4.67 per cent.

Average Score of the Cheese in Series 6.

Qualities.	Max.	A.	B.	C.	D.	E.
Flavor	40	37.05	37.65	37.40	37.50	35.28
Closeness	15	14.50	14.20	14.50	14.35	13.85
Even color	15	14.40	14.30	14.35	14.30	14.14
Texture	20	18.10	18.40	18.20	18.10	16.71
Finish	10	10.00	10.00	10.00	10.00	10.10
Total	100	94.05	94.55	94.45	94.25	89.98

The scorings show very little difference in the quality of the four lots of cheese. The B cheese which were put in boxes in cold storage directly from the hoops have the highest average score, while those ripened in the ordinary room are the lowest in the series as in all the others. The results indicate very forcibly that cheese may be put into a dry, clean, cheese box directly from the press, or after being one week in an ordinary ripening room, and then be put in cold storage at an average temperature of 38 to 40 degrees, and 90 per cent. humidity with very satisfactory results. These were the best cheese made during the season, and all those who judged them pronounced them "finest" goods. The large amount of mould which collected on the outside of the cheese in the box was the chief drawback. To overcome this a series of experiments with formalin were made.

7. Formalin Sprayed on the Cheese to Prevent Mould.

Cheese made April 22nd, 29th, May 6th and May 27th, which had as nearly as possible an equal quantity of mould on each, were put into boxes. One-half were sprayed with formalin, and the other were not sprayed. When examined on August 26th those not sprayed were found to be very mouldy, while those which had been sprayed on the ends of the cheese and very lightly in the box, and on the scale boards were quite free from mould. Other cheese put directly from the press into boxes in cold storage and sprayed with formalin were equally free from mould. This plan would seem to be a preventive of mould, but owing to the strong nature of the formalin, not many cheese could be treated at one time by the same person, and the expense would be considerable with a large number of cheese. Some better remedy will doubtless be found.

8. Paraffining Cheese.

Experiments were continued during 1902 with dipping cheese into paraffine wax at a temperature of about 180 degrees. The cheese were dipped at stages, directly from the press, at the end of one week, two weeks and three weeks.

The best results, in appearance, were got by dipping the cheese in hot wax about one week after they were made, and then placing the cheese in cold storage. For cheese ripened in an ordinary room, we can see no particular advantage in paraffining cheese. It tends to prevent the growth of mould, and prevents loss of weight while ripening. Recent reports from England say that the cheese which have been paraffined have not been well received on the markets of Great Britain. The chief advantage seems to be to prevent loss of weight while the cheese are held. It will probably pay the speculator to have the cheese coated, but it is a question whether it will pay the average factory-man to dip his cheese in paraffine wax at the present time.

Average Score of the Cheese in Paraffining Experiments.

Cheese.		Average flavor.	Average closeness.	Average color.	Average texture.	Average total.
When made.	Paraffined.	Max. 40.	Max. 15.	Max. 15.	Max. 20.	Max. 100.
Aug. 18.....	From press.....	36.94	13.94	13.61	17.44	91.94
Sept. 1 and Sept. 22. Ripened in cold storage..	Not paraffined..	37.00	13.94	13.77	17.44	92.16
Oct. 6 and 13....	From press.....	35.75	13.25	13.87	17.12	90.00
	1 week.....	36.37	13.00	13.50	17.12	90.00
	2 weeks.....	36.87	13.50	13.62	17.62	91.62
	3 weeks.....	37.25	13.62	13.87	17.37	92.12
Ripened in ordi- nary room. ...	Not paraffined..	37.00	13.75	14.00	17.62	92.37

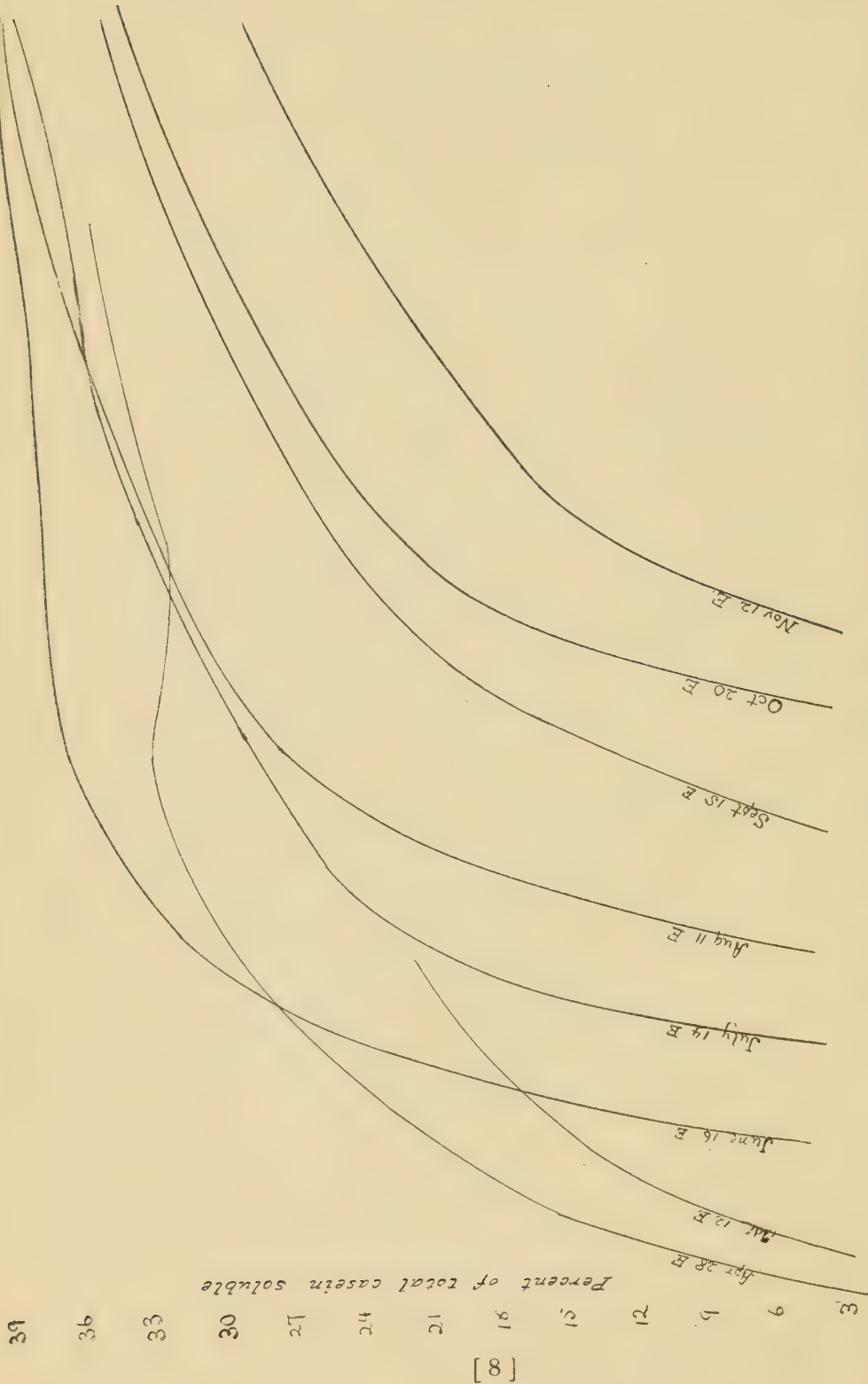
The cheese made during August and September were scored on November 22nd, 1902, and January 1 and April 14th, 1903, by Mr. G. H. Barr, as were also those made in October. The cheese not paraffined averaged slightly higher in quality, when full points were given for finish as in the other series. Taking appearance or finish into account, they scored lower. The average of three scorings for appearance on three lots of paraffined cheese made during August and September ripened in cold storage was 6.33 out of a possible ten, while the lots not paraffined averaged 3.55 points.

The October lots not paraffined also scored slightly higher when giving full points for finish. Taking appearance into account they scored an average of 6.5 points out of a possible ten. Those dipped at the end of three weeks scored 7.5, those paraffined in two weeks 8.0, those in one week scored 9.25, and those dipped in paraffine wax directly from the press scored an average of 8.75.

The chief gain was in the saving of shrinkage. The paraffined cheese lost no more than the weight of the wax which adheres to the cheese. Those dipped in one week lost .78 per cent., in two weeks 1.57 per cent., three weeks 2.36 per cent., and those not coated lost 3.16 per cent. in one month. The cheese weighed an average of about 30 pounds each.

ACIDITY OF THE MILK AND CURD.

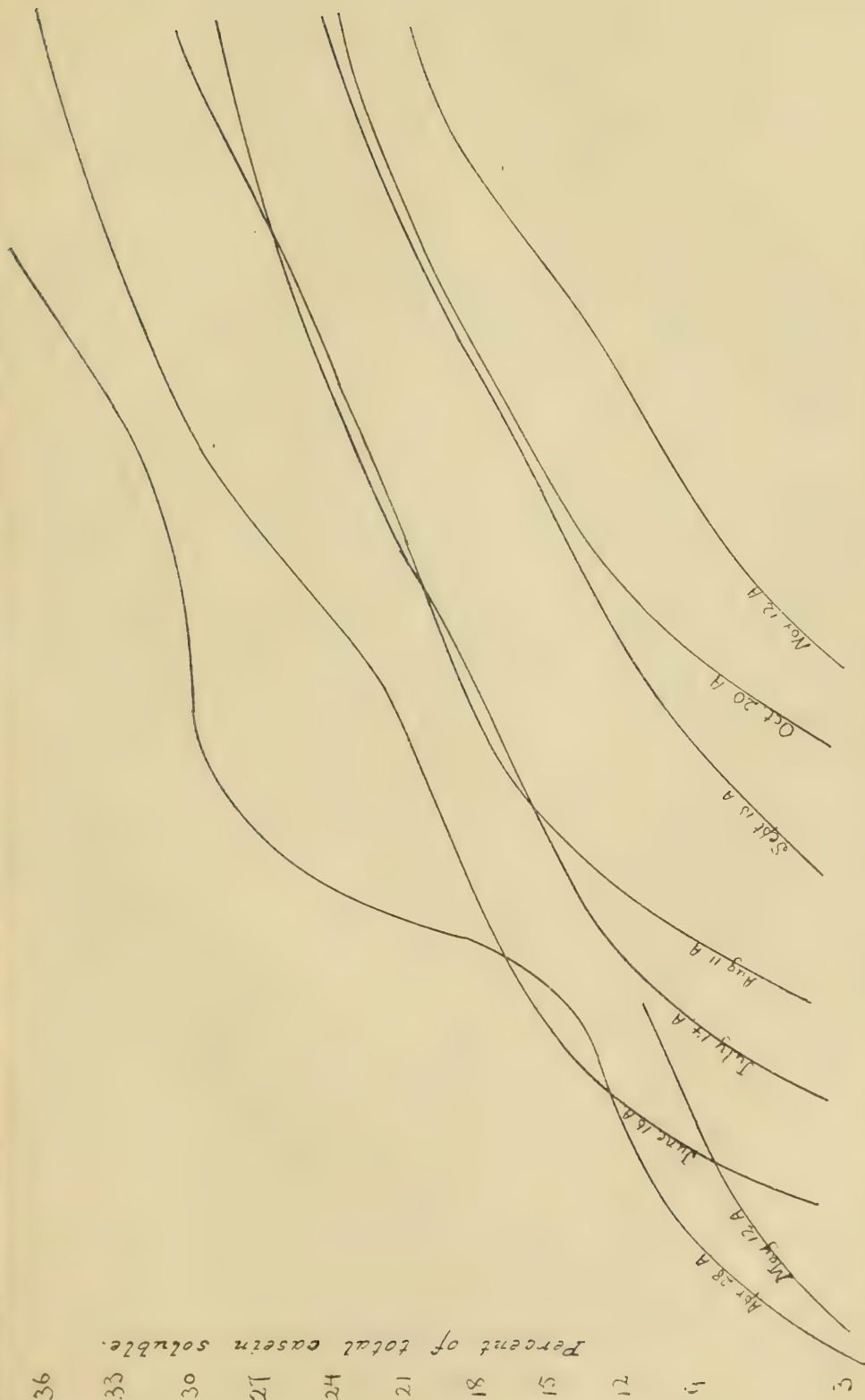
The acidity of the milk at the time of adding the rennet varied from .2 on June 9th to .23 on July 21st and September 8th. It averaged .216 for the sea-



Months through which the experiment was conducted.

Diagram Illustrating Rate of Ripening at 60° to 65° F.

Percent of total casein soluble.



Months through which the experiment was conducted.

May 1 June 1 July 1 Aug 1 Sept 1 Oct 1 Nov 1 Dec 1 Jan 1 Feb 1 Mar 1 Apr 1 May 1

Diagram Illustrating Rate of Ripening at 40° F.

son. At dipping, the curd ranged from .18 to .23 and averaged .198 for the season. When the curds were milled the acidity varied from .69 to .9 and averaged .806. At the time of salting, the acidity varied from .85 to 1.14 and averaged 1.005 for the season.

In our cheese work at the Dairy department of the College, we have practically discarded the rennet and hot iron tests, as the acidimeter is more convenient, less wasteful of material, and much more accurate in its results.

WHITE SPECKS IN CHEESE.

No white specks were noticed in the cheese ripened in cold storage in 1902. The only explanation we can offer is that the cheese were not allowed to go below freezing point in the winter of 1902 and 1903, whereas in the winter of 1901 and 1902 the cheese were below freezing point, and the white specks were quite pronounced in the cheese.

The general conclusions of Drs. Babcock and Russell of Wisconsin on this question are:

"The chief factors determining the formation of white specks in cheddar cheese seems to be that of temperature and salt. Low temperatures favor very much the production of these specks. Rarely do they appear at 60 degrees Fah., except where other conditions are peculiarly favorable for their production."

"The addition of salt tends to prevent their formation under all conditions. Also they are not so apparent when increased quantities of rennet are used. They are especially abundant in skim cheese, but do not appear in very rich cheese even at low temperatures. In sweet curd cheese no specks were found at any temperature."

THE EFFECT OF TEMPERATURE ON THE RATE OF RIPENING OF CHEESE.

There is every reason to believe that the ripening of cheese depends on the growth and chemical changes produced by ferments. Just what are the best conditions under which these ferments work is not definitely known, nor are the chemical changes that take place fully understood. It has been proved, however, that cheese will ripen more slowly, and will develop a milder, cleaner flavor and better texture at a temperature of 40 degrees Fah. than at 60 degrees Fah. All the chemical changes which take place within the cheese during the ripening process have not been studied out; but it is known that one of the most important is the changing of the insoluble casein into soluble compounds. These changes apparently take place much more slowly, especially in the early stages of ripening, at the lower temperature. In order to study the amount of casein rendered soluble and the comparative rate at which these changes take place under the two different conditions of ripening, a large number of analyses of cheese were made from month to month in 1901 and again in 1902. The cheese used in this work were marked A and E in series I of this bulletin, and cheese made and ripened under similar conditions in 1902, also marked A and E*. In both year's experiments the A cheese were placed at once in cold storage, the average temperature of which for the season was 38.9 degrees Fah., and E in ordinary ripening room, where the average temperature was 62 degrees Fah. An endeavor was made to determine the total amount of nitrogenous matter, or casein, the amount of casein soluble in

*See Bulletin 121, Ontario Agricultural College. Ripening of Cheese in Cold Storage Compared with Ripening in Ordinary Curing Room.

water, and the amount of ammonia, which is the end product in the decomposition of the casein, in A and E cheese for each month from April to November. With the exception of September, a monthly analysis was also made of each cheese made in 1902 from date of making to May, 1903. The analyses were not made so regularly in 1901, but enough was done to show the amount of casein rendered soluble monthly during a period of eleven months.

NOTES ON METHODS OF ANALYSES.

Sampling. In taking the sample for analysis, two plugs were drawn from opposite sides of the cheese by means of an ordinary cheese tryer and bottled at once. The sample was then chopped up fine inside the bottle with a thin spatula, well mixed, and tightly corked up. From this portions were taken for analysis.

Total Nitrogenous Matter, (principally casein). The nitrogen as determined by the Kjeldahl process, was multiplied by 6.25 to obtain nitrogenous matters.

Water Soluble Nitrogenous Water. Ten grams of cheese were ground in a porcelain mortar with sharp clean sand, transferred to a flask, treated with from 75 to 100 cc. of cold distilled water, and warmed in a water bath to 60 to 65 degrees C. as soon as possible. After reaching this temperature and after thorough stirring the liquid was poured on a pad of cotton wool in a glass funnel and filtered into a 500 cc. flask. Another portion of water at about 60 degrees C. was then poured on the sand and cheese, and the flask containing them replaced in a water bath at 60 to 65 degrees C. This operation was repeated six or seven times, with frequent stirrings, the water remaining in contact with the cheese from 15 to 30 minutes. Each extraction occupied from two to three hours. The cheese extract thus obtained was cooled and made up to a volume of 500 cc., and then filtered under pressure through a thick pad of asbestos. The nitrogenous matter soluble in water was then obtained by determining the nitrogen in an aliquot portion of the extract by the Kjeldahl process, and multiplying it by the factor 6.25.

Ammonia was determined in the original cheese by grinding a suitable quantity (usually 10 grams) with cold water in a porcelain mortar, transferring to a distillation flask, making alkaline with magnesium oxide (MgO) and distilling off the ammonia.

It is not, strictly speaking, correct to use the term "casein" when the total nitrogenous matter is meant; yet, as casein is the principal nitrogenous constituent of new cheese and the one best known to dairymen, it will be used in that sense in the discussion of results hereafter given.

RATE AT WHICH CASEIN IS CHANGED TO SOLUBLE COMPOUNDS.

The following table gives the average percentage of total casein in A and E cheese found soluble in water at the end of one, two, three, and up to eleven months. The figures do not represent the rate at which the casein in any one pair of cheese became soluble; but the average of all cheese for the season when one, two, three, etc., months old. The percentage of total casein changed to ammonia for the same periods is also given. These figures, therefore, represent the averages obtained from cheese one or more months from date of making at all seasons of the cheese-making year.

The average percentage amount of total casein changed to soluble and ammonium compounds per month for 1901 and 1902.

Age of Cheese.	1901.				1902.			
	A.		E.		A.		E.	
	Per cent. of total casein changed		Per cent. of total casein changed		Per cent. of total casein changed		Per cent. of total casein changed	
	to soluble compounds	to ammonium compounds.	to soluble compounds	to ammonium compounds.	to soluble compounds	to ammonium compounds.	to soluble compounds	to ammonium compounds.
1 month.	9.7	.....	17.7	.75	9.9	.....	17.6	1.5
2 months	14.6	.....	25.3	1.2	12.6	.....	23.1	2.2
3 "	15.4	.5	26.3	.....	15.1	1.5	24.7	2.3
4 "	16.9	.....	28.2	.....	17.8	1.5	29.8	3.1
5 "	18.2	.7	30.0	1.8	21.3	2.0	32.1	3.5
6 "	20.6	.8	32.5	2.5	22.4	2.1	33.1	3.4
7 "	.....	.....	.....	.....	24.3	2.7	34.9	3.9
8 "	26.9	2.3	37.5	3.5	27.3	2.6	36.8	4.2
9 "	26.5	1.5	37.1	4.2	29.1	2.8	38.1	4.4
10 "	28.2	2.8	38.3	4.5	29.0	3.0	38.7	4.6
11 "	32.9	2.8	40.6	5.0	.....	.....	.....	.....
Average monthly gain after 1 month.	2.26	.....	2.33	.....	2.13	.....	2.34	.....
Average monthly gain after 2 months.	1.97	.....	1.74	.....	2.06	.....	1.95	.....

Two points are particularly noticeable in this table. First, the E cheese contained at any given time more soluble compounds than the A cheese; and, second, the E's made most of their gain in solubility over the A's during the first month. Looking at the average monthly increases in solubility from the time the cheese were one month old given at the bottom of the table, it will be seen that in both years' work the E cheese gained a little faster than the A's; but that taking an average of the increases from two months on, the E's did not gain so rapidly as the A's. The casein of the E cheese was broken down a little more quickly during the second month than that of the A's; yet it is evident that the cheese ripened at the higher temperature made the most of their gain over those in cold storage during the first month and that from that time on they ripened fairly evenly. If we measure the ripeness of the cheese by the breaking down of the insoluble casein as shown by the percentage amount soluble the cheese kept at a temperature of from 60 to 65 degrees Fah. are as ripe at the end of one month as those kept at about 40 degrees Fah. are at the end of four months.

It appears as though the amount of ammonium compounds formed is somewhat proportional to the casein rendered soluble.

The percentage amount of total casein soluble in the different pairs of cheese at the time of the monthly analysis is given in the following table. The

first column gives the date of making and the succeeding ones the conditions of the casein immediately on taking from the press and at one, two, and up to eleven months from that time.

Percentage amount of total casein soluble in water at stated intervals in cheese made in 1902.

Date of Manufacture.	1 day.	Number of months from date of making.										
		1	2	3	4	5	6	7	8	9	10	11
April A..	.....	8.0	11.4	.....	13.4*	.....	31.2	28.1	31.1	31.6	36.7	....
28th E..	.....	15.5	22.8	.....	29.2	.....	33.0	30.7	32.3	33.8	37.3	....
May A..	2.7	7.4	9.2	11.2	Disca	rded o	n acco	unt of	devel	opment	of	■
12th E..	2.7	14.1	17.9	21.8	bad	flavor.						
June A..	4.0	13.5	16.3	.....	21.6	21.6*	29.2	28.5	32.4	34.1	34.8	36.6
16th E..	4.0	22.7	31.8	.....	36.5	37.9	37.1	37.2	38.9	38.1	40.5	39.5
July A..	3.7	12.1	.....	16.5	18.1	21.9	22.3	26.2	26.4	27.7	29.0	....
14th E..	3.7	22.1	.....	28.9	30.1	33.7	34.7	35.8	36.7	37.0	38.7	....
Aug. A..	4.3	.....	17.4	18.5	20.6	23.1	25.3	24.8	31.1	30.5	.....	....
11th E..	4.3	.....	28.8	29.7	32.5	34.1	37.9	35.8	38.8	39.2	.....	....
Sept. A..	.....	9.7	11.1	16.1	15.3	20.1	21.7	23.5	24.6	.....	.....	....
15th E..	.....	16.6	22.0	21.1	28.2	30.9	32.1	33.7	35.0	.....	.....	....
Oct. A..	3.6	10.5	13.7	15.7	19.6	20.3	24.3	22.9	.....	.....	.....	....
20th E..	3.6	18.0	21.3	25.5	29.2	29.7	32.2	34.3	.....	.....	.....	....
Nov. A..	.....	8.2	9.3	12.5	16.2	20.5	18.5	.....	.....	.....	.....	....
12th E..	.....	14.0	17.2	21.5	22.6	26.2	28.8	.....	.....	.....	.....	....

* A and E cheese reversed at this point.

Here again it is evident that the casein of both cheese of each month was changed to a soluble form faster during the first month than during succeeding months and that the casein of E cheese became soluble much more rapidly than A. This is also true, although the development was slower, in the second month; but from that time on the cold storage cheese seemed to ripen as rapidly as those at the higher temperature. As the most rapid gain of the E's over A's is not so great during the second month, it is possible that the first six weeks covers the time during which the former ripens faster than the latter.

Another point worthy of notice in this table is that the cheese made in June, July, and August contained a larger amount of soluble compounds at the time of taking from the press than those made in the spring and fall. They also gained in solubility, or ripened, much faster than those made in other months. This applies to those kept in cold storage as well as to those kept in the ordinary ripening room, and is doubtless due to the difference in the condition of the milk, or its germ content, at that season of the year; for, the milk was brought to the same degree of acidity before adding the rennet and treated the same throughout the after process in all the different experiments.

When the April cheese were four months old, or in August, the A and E cheese were reversed; that is, A was taken out of cold storage and placed in the ordinary ripening room at a temperature of 60 to 65 degrees Fah., while E was taken from this latter room and placed in cold storage. Notice the very rapid gain in the amount of casein soluble from the fourth to the sixth months in A, while the rate of change in E became slower. The June cheese were reversed in November and the same changes are noticeable. Why the results should be lower in some instances than they were in the preceding month, as, for example, the sixth and seventh months of April cheese, cannot

be explained, unless it is due to errors in sampling. As cheese is a mixture of substances, no assurance can be given that the two plugs taken as a sample always accurately represented the whole cheese. Yet larger samples could not very well be taken when the analyses were to be continued for a number of months. At the same time, the monthly analyses probably give results which fairly well represent the changes in the solubility taking place during the ripening process.

The curved lines in the accompanying diagrams graphically represent the rate at which casein changed to soluble compounds in the cold storage cheese as compared with those ripened at the higher temperature. Notice how much more perpendicular the first part of the lines representing E cheese are than those representing A cheese. It will be remembered that April cheese were reversed in August; notice the abrupt upward curve of the line representing A cheese at this point. June cheese were reversed in November, but the upward curve following the change is not so pronounced as in the preceding case. Possibly this is due to the casein being at a more advanced stage of decomposition when the cheese were changed. Another noticeable point is the similarity in the rate of ripening of July and August cheese under A and E conditions. The same may be said of September and October.

The quality of the cheese under the two methods of ripening has been dealt with on page 2 of this bulletin; but for purpose of comparison, the total scores and the time at which they were made are given in the following table:

Total scores at several different dates.

Date of Manufacture.	Number of months from date of making.										
	1	2	3	4	5	6	7	8	9	10	11
April A.....			89.0	*							
28th E.....			85.0	84.0		89.0		85.6			
May A.....		83.0	77.0		77.0			83.0			
12th E.....		79.0									
June A.....				93.0	94.0*	95.0					
16th E.....		85.0		91.0		87.0				87.0	89.0
July A.....			95.0		96.0		92.0				
14th E.....			92.0		89.0					95.0	
Aug. A.....									85.5	86.0	
11th E.....		90.0		85.0		92.0		93.5	99.0		
Sept. A.....									84.0		
15th E.....		91.0	84.0		91.5		96.0	95.0			
Oct. A.....				92.5			81.0	73.0			
20th E.....	89.0	86.0				96.0	98.0				
Nov. A.....			96.0		93.5	96.0	91.0				
12th E.....	89.0				88.0	88.0					

* A and E cheese were reversed at this point.

Unfortunately, the scoring was not followed regularly on the April and June cheese after the A's and E's were reversed. The score indicates that the cheese kept in cold storage have a much longer commercial life than those ripened at a higher temperature.

THE INFLUENCE OF SALT ON CHEESE.

In some investigation work done by Mr. H. Rive, B.S.A., in connection with his graduation thesis, the cheese made as outlined in series 5 of this bulletin, were analyzed. From the results he obtained, the percentage of salt,

moisture, and total casein soluble, as affected by the two quantities of salt used, are selected. The twelve cheese were examined twice—once when they were two, three, and four months old, and again when five, six, and seven months old. The results reported under two and five, three and six, four and seven months are from the same cheese; and as there were two pairs of cheese each month, each result is an average obtained from two cheese. The following are the results:

Effect of different quantities of salt on the amount of moisture and salt retained, and on the rate of decomposition of the casein of cheese.

Age of cheese.	Per cent. of salt retained when curd was salted at the rate of		Per cent. of water retained when curd was salted at the rate of		Per cent. amount of total casein changed soluble compounds, salted.	
	2.25 lbs. per 100 lbs. curd.	2.75 lbs. per 100 lbs. curd.	2.25 lbs. per 100 lbs. curd.	2.75 lbs. per 100 lbs. curd.	2.25 lbs. per 100 lbs. curd.	2.75 lbs. per 100 lbs. curd.
2					12.5	11.6
3					22.2	20.3
4					21.6	20.2
5	1.50	1.64	33.97	33.19	23.2	21.9
6	1.72	1.92	34.01	32.88	27.5	26.5
7	1.75	1.98	33.83	33.25	26.0 *	24.0 *
Average....	1.66	1.84	33.91	32.10	.....	.....

* From one cheese only.

According to these results, one-half pound more salt decreased the amount of moisture by nearly one per cent. It also retarded the rate at which casein was changed to soluble compounds. The amount of salt retained in ripe cheese is not in proportion to the quantity added. If the heavier salted cheese retained salt at the same rate as the lighter salted ones, they would have contained 2.03 per cent. instead of 1.84. Two years ago Dr. Van Slyke, New York State Experiment Station, Geneva, drew attention to results similar to those just given*. His experiments were conducted with cheese ripened at 70 degrees Fah., while those used in this experiment were ripened at a temperature of 40 degrees Fah.

CONCLUSIONS.

1. The cheese ripened in cold storage at a temperature of about 38 degrees were much superior in quality to those ripened in an ordinary ripening room at a temperature of about 62 degrees. The chief improvement is in flavor and texture. The cheese ripened in cold storage have a mild, clean flavor and silky texture, while those ripened in the usual way were more liable to be "off flavor" and "mealy" in texture, especially when from three to six months old, at which time those ripened in cold storage are beginning to get in good condition for eating. These results correspond with those obtained in 1901.

2. If we measure the ripeness of the cheese by the amount of casein changed to compounds soluble in water, the cheese kept at the higher temperature were as ripe at the end of one month as those kept at a lower temperature were at the end of four months.

3. The cheese placed in the ordinary ripening room ripened much faster during the first month, a little faster during the second month, but more slowly during the succeeding months than those placed in cold storage.

*Report of Ontario Dairymen's Association for 1901.

4. The cheese made in the months of June, July, and August ripened faster, both in the ordinary ripening room and in cold storage, than those made in the spring and fall months.

5. The cheese which were ripened in cold storage for periods of one to three months and then moved to an ordinary room, did not deteriorate rapidly after moving, but those allowed to remain in cold storage for the longest period were the best in quality. So far as those experiments indicate there is no risk in moving cheese, which has been ripened in cold storage, to an ordinary temperature for a reasonable length of time.

6. When cheese were removed from cold storage and placed in the ordinary ripening room the rate at which casein was decomposed increased, while, when the change was made in the opposite direction, apparently the reverse was true.

7. An extra quantity of rennet used in making some of the cheese placed in cold storage appeared to improve the quality as compared with cheese made in the other series, although no direct experiments on this point were made in 1902. The results also indicate that if a large quantity of rennet be used, the cheese should be placed in cold storage soon after being made in order to obtain the best results.

8. An increased yield of cheese equal to one or two per cent. may be obtained by using an extra quantity of rennet, and by cooking to 94 degrees, and by salting lightly, but the quality of the cheese made in this way in 1902 were not so good as those of 1901. At present we do not recommend cheese makers to try to leave more moisture than usual in the curd where cheese are to be placed in ice cold storage, though later experiments indicate that it may be all right for cheese ripened in mechanical cold storage.

9. From the results obtained during the past two years it would appear to be quite feasible to place cheese boxes in cold storage either directly from the press or after remaining a week on the shelves. This plan means a great saving in labor, and a saving of shelf room. The chief drawback is the growth of the mould on the cheese. This can be overcome to a large extent by spraying formalin on the cheese and in the boxes. The boxes should be clean and dry.

10. Dipping the cheese in paraffine wax at a temperature of 180 degrees makes a light coating over them, which prevents loss of weight while ripening or when held in cold storage. It also tends to prevent the growth of mould, and to some extent improves the appearance of the cheese, especially when placed in cold storage. So far as our work has gone we are not prepared to recommend the general paraffining of cheese to the ordinary factoryman. If the cheese are acceptable to British buyers, it would seem that the speculator in cheese is the person who would receive most profit from the process.

11. No "white specks" were noticed in the cold storage cheese of 1902, which we attribute to the fact that the cheese were not allowed to go below 32 degrees Fah. as they did in 1901, when the "white specks" were observed.

12. The amount of salt retained in cheese was not in proportion to the amount added.

13. When curd was salted at the rate of 2.75 pounds of salt per 100 pounds of curd, there was less water in the cheese, and the rate at which casein was changed was slower than when 2.25 pounds of salt were used.

14. Cheese ripened at a low temperature ripened more slowly during the first month or six weeks than those kept at a higher temperature; but after this period one ripens as fast as the other.

Ontario Agricultural College and Experimental Farm

ROUP: AN EXPERIMENTAL STUDY.

PROF. F. C. HARRISON AND DR. H. STREIT, BACTERIOLOGICAL DEPARTMENT.

One of the most important poultry diseases in America is fowl diphtheria, more often called "Roup." It is very widespread; but it is more prevalent in some places than in others; thus, for example, it is said to be almost unknown in the Canadian Maritime Provinces and in Eastern Ontario, while in Southern Ontario it is the most prevalent disease of fowls.

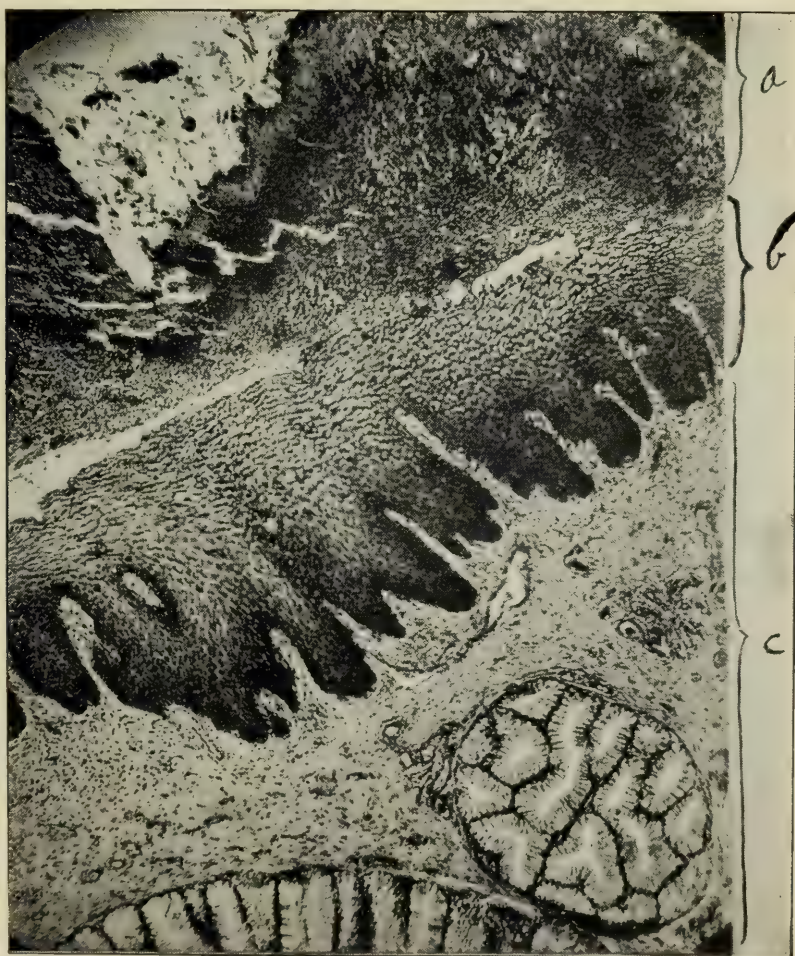


Fig. 1.—A section of false membrane of rousy fowl (No. 9). *a*. The false membrane partly separated from the middle epithelial layer. *b. c.* Submucosa. *d*. Normal mucous glands.

The views of poultry raisers as to the origin of roup differ very much. A small number trace it to a neglected case of ordinary cold or catarrh, basing their belief on the fact that among fowls living under hygienic conditions,

where even common colds receive prompt attention, roup is quite unknown ; but by far the greater number of breeders consider roup a more or less infectious disease, which is said to be produced by a certain micro-organism. This view is strengthened by accounts of the disease in the literature of poultry breeders, according to which epidemics have been caused by diseased fowls being brought into healthy flocks.

There is also an impression among poultrymen that fowls that have once overcome the disease possess a certain degree of immunity.

In America, V. A. Moore is the only person who has examined roup scientifically. The results of his investigations, however, are insufficient to establish the etiology of roup, and hence the need of further research.

For several years in succession roup has made its appearance in the poultry yards of the Ontario Agricultural College, usually during the cold, damp weather of late autumn and early winter. It usually causes a direct loss of from 10 to 15 per cent., and a much larger indirect one from the disease becoming chronic. It often lasts for months, and makes the fowls attacked absolutely worthless either for table use or for breeding ; and the most valuable fowls of the special breeds are the ones most frequently attacked by the disease. Young birds, six months or a year old, are particularly susceptible.

CLINICAL SYMPTOMS.

In the majority of cases, the first symptoms of roup appear in the nostrils. Moore found the disease most frequently localized in the eyes ; while, according to the statements in German, Italian, and French literature, the mouth, pharynx, nostrils, and wind-pipe are the places in which the first symptoms of the disease usually appear.

Over 300 cases of the disease have been studied at this institution. Thirty-six of the most severe were examined daily for several months. Of these, four recovered ; and the others died, or were killed for dissection.

NOSE.

Nose. Roup usually appears first in weak fowls as catarrh of the nose. At one or both nostrils a serous fluid is observed. Occasionally on a cold night in autumn or early winter a large part of the flock is suddenly attacked by catarrh ; and next morning as many as three-fourths of the fowls show a serous nasal discharge. In from three to eight days many fowls under normal conditions recover from this catarrh, without any further result. In others, however, both the general and local conditions grow worse, and develop through all the different stages of roup.

The serous nasal secretion soon becomes streaked with grey ; a slimy matter forms and dries quickly to dirty crusts, which often completely close the nostrils. The secretion never becomes yellow, as, according to Zuern and Friedberger-Frochner, is said to be the case in European fowl diphtheria.

On the removal of the crusts around the nostrils, a few drops of grey secretion flow out. These can be increased by pressing the nostrils. In later stages, small, solid, yellowish-white particles of matter are often found

in the grey nasal secretion. The secretion decomposes and emits an offensive odor. On the mucous membrane of the nostrils, small cancers form ; or the whole nostril is completely filled with a firm, whitish-yellow cheese-like mass, which frequently grows very rapidly and separates the nostrils and forces the dorsal wall of the nostrils upward. This mass soon becomes dry and brown on the outside ; and it adheres quite firmly to the mucous membrane. If it is removed, it quickly forms again.

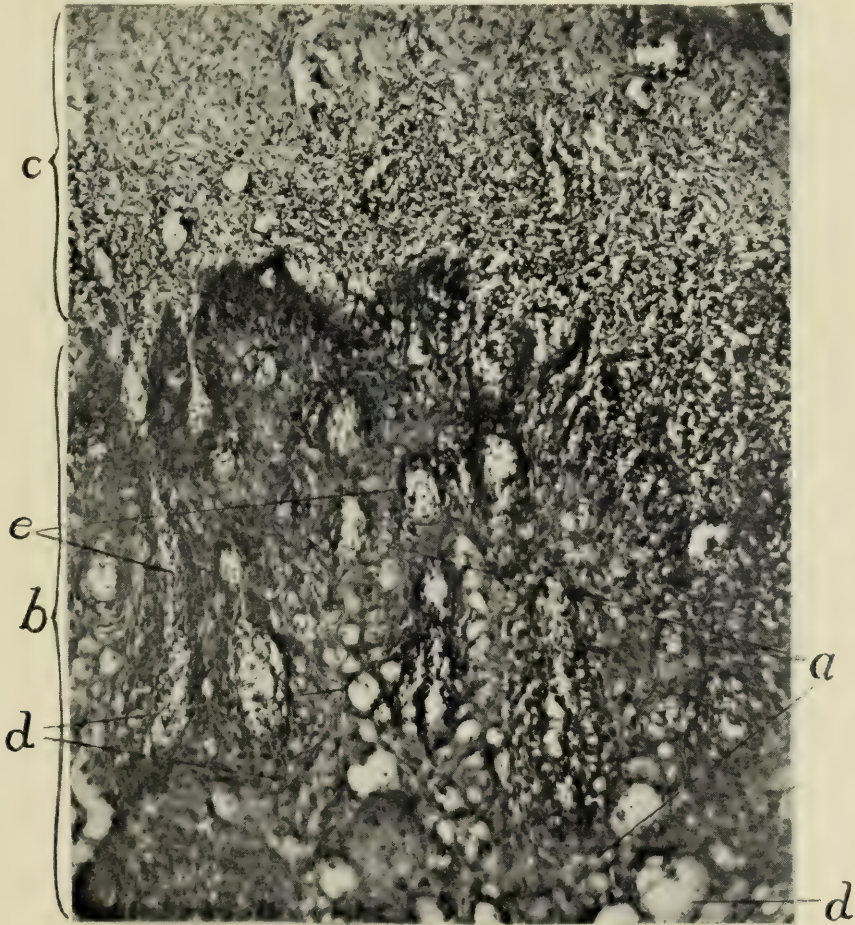


Fig. 2.—A section through the deeper epithelial layer under a firmly attached false membrane. *a*. Swollen epithelial nuclei. *b*. Epithelial layers dislodged from their normal position. *c*. Submucosa infiltrated by leucocytes. *d*. Homogeneous fibrinous exudate. *e*. Mixed fibrinous and purulent exudate.

As the changes above described progress, it becomes impossible for the bird to breathe through the nostrils, and the beak is kept open for breathing. In the early stages of the catarrh, the irritation causes sneezing ; but later this symptom disappears.

EYES.

From the diseased mucous membrane of the nostrils, the inflammation easily spreads to the mucous membrane of the mouth, pharynx, and larynx ; yet, these parts may be the first seat of the infection. When the disease affects the eyes,

there is often formed in the inner corner of the eye a viscous, lacrymal secretion, which contains air-bubbles. These bubbles come from the nose, and are forced into the eye through the lacrymal duct, because the natural air-passage through the nostrils is half stopped up and the air finds this outlet.

Soon a serous Conjunctivitis forms. The Conjunctiva becomes very moist, swollen and grey. The secretion gradually assumes a slimy, purulent condition. The lids swell oedematously, and become perceptibly thicker in a single night. They are hot, sore, very much inflamed, and stick together very easily, because the eye at this stage of the disease is, for the most part, kept shut. Often the lacrymal duct remains open, and the secretion passes out into the nasal or pharyngeal cavity. In all the more severe cases, however, this canal is completely closed. The accumulating secretion frequently overflows into the inner corner of the eye, and defiles the surrounding region with greasy crusts of dried secretion. The small feathers on the side of the head stick together, and often fall out. When the lids stick together, they are forced outwards by the masses of secretion formed under the eye. The secretion consists of a somewhat thin, clear, or turbid fluid, containing jelly-like lumps, which are clear or striped with grey. The gelatinous masses are formed by a homogenous, or lightly striped, unstainable substance, mingled with pus corpuscles, epithelial cells, and bacteria. The grey parts are much richer in leucocytes than the clearer ones. The epithelial cells are ciliated, with or without a swollen unstainable nucleus. The free epithelial nuclei are usually very much swollen (as large as 16m.m.m.), round, homogenous, or slightly granular and unstainable. In the centre of the nucleus there may be found one or two small, round bodies which can be stained.

If the secretion is left in the closed eye-lid, it may be completely changed in 24-48 hours to a firm, smooth, yellowish-white, cheese-like body, which fills up the whole eye-lid, and lies like a cap over the bulbus oculi. This cheesy mass may become so large that it forces the lids open, and projects between them. The outside then dries and becomes a brownish crust. Moore explains the formation of these cheesy masses by assuming that the liquid content of the eye-lid undergoes coagulation; but, as stated above, they (the cheesy masses) are formed from jelly-like masses in the eye-lid. In all probability, the secretion is an abnormal product of the lacrymal glands and conjunctiva, and contains epithelial cells, as well as free swollen epithelial nuclei.

The grey spots of these gelatinous masses contain very many round cells. The greyer, firmer, and more turbid this mass becomes, the more numerous are the cells. When the mass finally assumes the cheese-like appearance, it consists of leucocytes, granular detritus, epithelial particles, and bacteria. The yellow cheese-like masses are produced by the pus corpuscles exuding in large numbers on to the surface of the mucous membrane, where they stick together, mix with the pathologic secretions, and probably with coagulable plasma. If the gelatinous masses are removed from the eye-lid and allowed to dry, they become a dirty, grey crust.

It is astonishing with what rapidity cheesy masses that have been removed form again. Thus, from hen 11, cheesy masses, the size of marbles, were re-

moved from the same eye on three successive days. These solid masses can be easily removed ; but they may sometimes adhere to a croupous membrane on the mucosa.

In the further course of the Conjunctivitis, small croupous membranes appear on the Conjunctiva, and on the swollen lids, or the mucous membranes. These usually adhere closely ; and, on their removal, the mucous membrane begins to bleed.

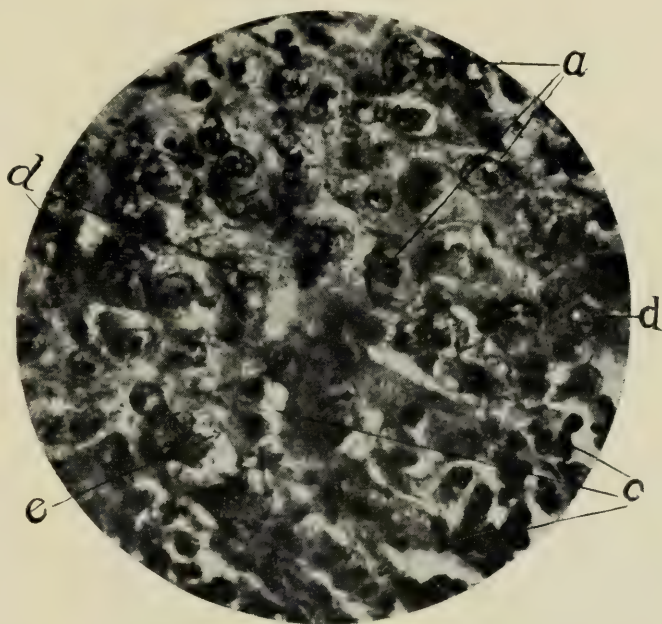


Fig. 3.—Section through the deeper epithelial layer under a firmly attached false membrane from hen No. 9, magnification 700.
a. Swollen epithelial nuclei with 1 or 2 well-stained nucleoli.
b. Nucleus of normal size granular staining. *c.* Leucocytes and fibrinous exudate. *d.* Granular detritus. *e.* Two short bacteria.

The Cornea may also become a direct seat of the disease, in which case small croupous membranes form on it. These may remain on the Cornea, or spread over the Conjunctiva of the bulbus oculi. Often the membrane grows through the whole Cornea. If it falls off, the interior eye cavity is either directly opened, or the remaining layer of the diseased Cornea is too thin to resist any following perforation. After the opening of the eye-cavity, a prolapse of the lens may occur ; and following this, a purulent ophthalmia develops. After the destruction of one eye, the other usually becomes sympathetically diseased. If both eyes have been originally the seat of the disease, panophthalmia may form on both sides.

The swellings in the eye-lids may remain the same for a long time ; but, frequently, the swelling spreads under the inner corner of the eye towards the nostrils. The lids, as well as this tumour, have a high temperature ; and are at first soft and oedematous. Later, indurations form in the centre, which become larger and larger, and at last lie directly under the skin. The outside of these indurations is rough or smooth, and the skin on it may be moved. In rare cases, an abscess forms instead of the induration.

Besides the indirect affection of the eyes from the nostrils, there is a more direct way which is also very common. In such a case the cella infra-orbitalis is generally affected from the beginning of the roudy, nasal catarrh, and the retained secretions become so large that the bone-walls are pressed out in all directions. Later, these, under the ever-increasing pressure, become absorbed in some places ; as, for example, between the inner corner of the eye and the nostril. Here a hot tumor with a hard centre forms. The swelling quickly extends to the eye-lids, after which serous putrid, croupous-diphtheritic Conjunctivitis sets in. These tumors are well known among poultrymen, for they frequently recommend the opening of the tumors and "extracting the roots of the disease." The masses taken from the tumors form again, with great rapidity and obstinacy. Often, after there had been for an indefinite period only a slight swelling on the lids, even without conjunctival catarrh, blindness ensued without any preceptible cause. Later, the iris and pupil became grey, and the cornea cloudy. When the disease of the eye appeared in this way, the general condition was always very much disturbed. In these cases, the post-mortem examination showed that the phlegmonous processes had spread from the eye-lids into the loose tissue of the peri-orbital cavity ; and grey, streaked pus, or thick, well-marked, yellowish-white, cheese-like lumps of matter, like those in the eye-lid, were found.

MOUTH AND PHARYNX.

Mouth and Pharynx. Primary or secondary catarrh of the nose, croupous or diphtheritic membranes appear on the mucous membranes of the mouth and pharynx, especially about the fissure of the palate, on the hard palate, on the side of the mouth, near the larynx, and under the tongue. They are usually small, but they often grow to large, extended patches. The thickness varies from $\frac{1}{2}$ -4m.m. The outside is uneven or smooth. The color is yellowish-white ; in the older membranes, a light brown. They either adhere firmly, or fall off easily. In the former case, they leave a dirty, greyish mucous membrane which bleeds slightly ; in the latter case, the underlying mucous membrane appears unchanged. A slight reddening of the region of the mucous membrane affected, may precede the appearance of the pseudo-membranes. Usually, however, this is not the case ; but the mucous membranes is pale, with a grey surface, which can be easily removed as a thin membrane. This grey superficial membrane gradually changes to a croupous or diphtheritic membrane.

In fowls 1, 4, 9, and 10, the first stages of a diphtheritic membrane were present, and the ducts of the sub-lingual glands were filled with a clear, tough, gelatinous secretion, which was turbid, and which finally became a solid yellow-white membrane. At first, these membranes were arranged in lines on both sides near the tongue. Later, they spread farther and became a single large membrane. In addition to this, in fowl 9, there developed a large tumour in the submucous tissues, which contained a firm, cheese-like lump directly adherent to the membrane. Frequently large swellings in the region of the sublingual glands occurred, which then hardened to firm, smooth, or uneven

tumours, while the mucous membrane of the mouth remained apparently normal. These tumours enclosed the above-mentioned cheese-like masses.

The pseudo-membranes in the mouth may appear in a third way, which usually happens in more severe types of the disease. The *Cella infra-orbitalis* becomes distended on all sides by the secretion retained in it. For this reason, it presses the palate towards the mouth-cavity. The palate, therefore, may thus attain twice and three times its regular breadth (as in fowls 5 and 27). Where the pressure is strongest, the bone stratum becomes absorbed, and a typical pseudo-membrane forms. This latter may easily be removed; and if left it communicates directly with the firm cheese mass in the infra-orbital cavity.

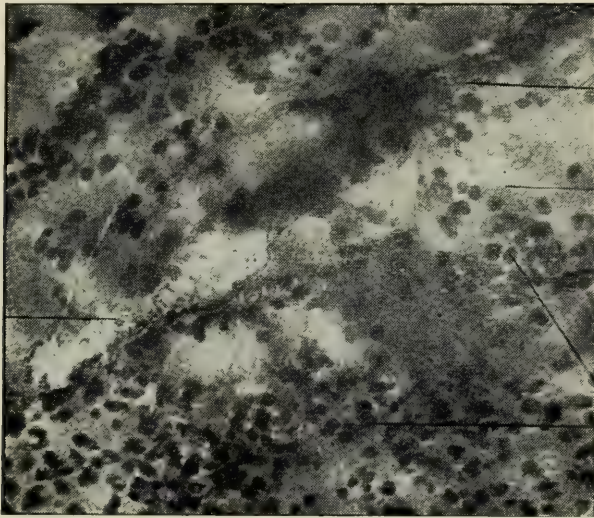


Fig. 4.—Section through a firmly attached false membrane from hen No. 17. *a* An altered epithelial nucleus not quite in focus, and consequently, not sharply outlined. *c*. Nuclei of the leucocytes. *d*. Granular detritus. *e*. A number of bacteria in the middle of an homogeneous fibrinous exudate.

In fowls 14 and 17, in addition to diphtheritic membranes on the mouth near the angle of the beak and at the nostrils, tumors were formed on the skin. These grew to the size of a pin head, or the pit of a cherry. The feathers on the tumours fell out, and the skin beneath was found to be covered with grey scales. The tumours were in direct connection with the pseudo-membranes on the mucous membranes, and formed a grey, dry, crumbly mass.

While in the cases under observation, the region around the larynx was very often the seat of croup-membranes, the disease never passed into the larynx or the trachea. Yet, according to the statements of many others, these organs are favorite places for the development of pseudo-membranes in the course of American Fowl Diphtheria.

Severe pneumonic dyspnoea appeared in fowls 1, 6, 12, 18, and 19. The thoracic walls were used for inspiration and expiration. The beak and larynx were always kept open. The visible mucous membranes, the crest, and the wattles became cyanotic. The dyspnoea grew worse and worse, and led to suffocation in 1 to 4 days.

In fowls that had been sick a long time, catarrh and inflammation of the bowels set in (hens 3, 4, 13, and 18). The fowls then stopped eating altogether. A severe, putrid diarrhoea followed; the feathers around the cloaca became smeared and matted with greyish-yellow, fluid excrement; and the fowls soon became as thin as skeletons, and usually died from loss of strength.

GENERAL SYMPTOMS

Corresponding to the polymorphic local appearances of roup, the general symptoms are also very different. As long as the disease exists only in the form of simple catarrh of the nose, slight affections of the mucous membranes of the mouth, and of the lungs, the general condition is quite normal. In all chronic, or more severe cases, especially after the appearance of swellings on the face and eye-lids, the general condition is disturbed. The sick fowls become weak, separate themselves from the other birds, and cower in a corner

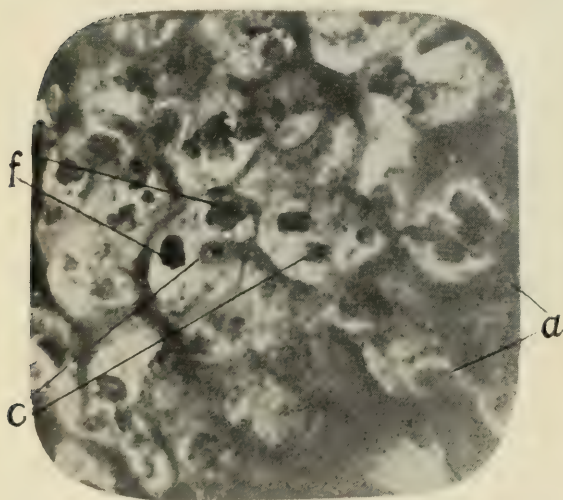


Fig. 5.—Section through the newly formed diphtheric membrane from hen No. 28. *a*. Swollen epithelial nuclei which stained but slightly. *b*. Remains of epithelial nuclei associated with Kitt's "Molluscum bodies" in the epithelial cells.

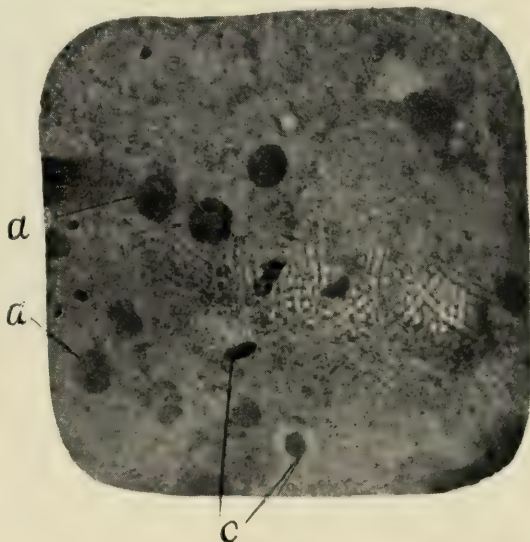


Fig. 6.—Cover-glass preparation from the upper epithelial layer under a false membrane of hen No. 18 stained with methylene blue. *a*. Much swollen epithelial nuclei with or without nucleoli. *c*. Nuclei of leucocytes.

of the yard with head drawn close to the body. The eyes are kept shut, and the head is often drawn under the wings, so that the feathers are smeared with the secretions and fall out. The birds often wake up from this sleeping position, rise, open their eyes, shake themselves, scratch the swollen places with their feet, walk around a few steps, and take some food or water, and sink back again into their apathetic condition. Usually the disturbance of the general condition fluctuates, that is, the birds for a few days often appear in better condition, or normal, and then become worse again. Towards death, they lie down on the floor of the cage and usually do not get up again.

At first, the appetite is not impaired; later, it fails, but often continues for a long time. The taking of food may become quite impossible from purely

mechanical reasons. For example, with fowl 5, the lower mandible was dislocated by the cheesy mass in the nostrils and infra-orbital cavity, and could not be closed. In many cases, there is a pronounced thirst. The fleshy condition of fowls attacked by roup usually becomes worse with the chronic continuance of the disease. The flesh of fowls which die after a short attack, is less affected. As for the body temperature of birds with diphtheria, it is the universal statement that the body temperatures are high in diseased birds. The English and American text-books on poultry all speak of fever as the constant accompaniment of roup. But, according to our observations, their statements on this point are incorrect; and our conclusions are confirmed by the investigations of Friedberger-Froehner. The temperature of the head is very often above normal; but in numerous cases in which we have taken the body temperature of roupy birds, there has been no increase; or at least, no considerable increase. The highest temperature that we ever found was 42 degrees C. in a perfectly healthy hen. The minimum temperature of healthy, as well as diseased, fowls, was 40.2-40.8 degrees C., the average being 41.5-41.8 degrees C. In all simple catarrhs of the nose the prognosis is a favorable one. As soon as complications set in it becomes bad.



Fig. 7.—Fowl No. 47 inoculated with *B. pyocyaneus*.

The course of roup, with few exceptions, is chronic; it lasts weeks, and even for years. Certainly the cause of its becoming chronic lies for the most part in the condition of the exudations or diseased secretions and their localization. Slighter affections of the nose very frequently disappear. If, however, the conchae or the infra-orbital cavities are attacked, or the nose passages become filled with solid masses of exudation, a natural recovery is either impossible or very slow. As has been described, these firm exudation masses become very large in a short time; they act like foreign bodies, setting up irritation, and become larger and larger by the continued transudation; and, by reason of the pressure of these bodies, various kinds of hypertrophies and atrophies ensue. They can be discharged only after having become softened and

liquefied ; and such cases appear but seldom, while the cheesy matter in the nose, as well as under the skin, shows no inclination to become so. They therefore, remain where they were formed, and lead to chronic catarrh. Often there is apparent recovery, so that for a few days or weeks, the clinical symptoms vanish. Then the catarrh again becomes manifest. These cases of apparent recovery are very important, as birds in this condition spread the disease if put among healthy ones. The pseudo-membranes in the mouth and pharynx may be of a very transitory nature. They appear first here, and then there, and but seldom disappear permanently, so long as any of the other



Fig. 8.—Pigeon (No. 6) 13 days after inoculation with culture of the Roup bacillus, (*B. cacosmus*) and two days before death.

symptoms of roup are present. In some cases (hen 28), the pseudo-membranes form again with great obstinacy in a certain spot. In these cases, poultrymen describe the trouble as cancer of the mouth. In a few exceptional instances, death occurs after a short sickness. Hen 9 died in this way after symptoms of roup had been recognizable for only two days. This bird showed a strong, hemorrhagic inflammation of the mucous membrane in the olfactory region, as well as swollen vessels in the meninges. Usually, however, death does not come until the disease has run for some time. The direct causes of death are anaemia, suffocation, inability to take nourishment, inflammation of the brain from the nose or eyes, invasion by decaying products of albuminoid substances, and intoxication with bacterial poisons.

PATHOLOGICAL ANATOMY.

In addition to the pathologic-anatomical changes already cited in the clinical account, the post-mortem examinations furnish other data. In diseased hen 9, mentioned above, the nasal passages were completely closed by dry, cheesy masses, without any apparent clinical symptom. The bird had been sick two days and showed small bloody extravasations in the upper parts of the nasal mucosa. The mucous membrane itself was very much inflamed.

The eyes were quite normal. The cheesy mass must, in this case, have formed very quickly, and without being preceded by serous-purulent catarrh. This, however, was the only case in which there was hemorrhagic inflammation. The diseased mucous membranes were, in other cases, always swollen; but dirty grey, or brownish in color. They were covered with a grey, putrid mass. Sections through the mucous membrane showed the epithelial cells with cloudy, or finely granular, protoplasm. The nuclei were, in most cases, normal; some were swollen, homogenous, and difficult to stain, excepting one or two extra round central corpuscles, which stained deeply. Many leucocytes were present between the epithelial cells. They were usually rather long in shape,



Fig. 9.—Head of fowl 36, 22 days after inoculation with a culture of the Roup bacillus. *a*. Firmly adherent thick diphtheritic membrane upon the conjunctiva of the upper eyelid.

and were found migrating towards the surface. The sub-mucous tissue showed a numerous increase of leucocytes, and dilated vessels. The leucocytes which migrated to the surface of the mucous membrane became free, and often joined the firm, cheese-like bodies which have been described. As these grew very quickly, they produced various deformities.

The mucous membrane may disappear entirely, or be changed to a brownish tissue of round cells, which are identical with the pyogenous membrane enclosing the cheesy matter in the sub-mucous tissues, etc. In one case (diseased hen 1), part of the mucous membrane of the nose was dry and necrotic. It consisted of a yellowish, dry, crumbly mass, which easily fell away from the cartilage. The latter was itself necrotic. Very often the medial wall of the infra-orbital cavity was absorbed, and then the solid mass of cheesy matter was in direct connection with that in the free nasal cavities. For this reason, the cheesy mass appeared to have grown fast, which, however, was not the case.

In fowl 28, a large part of the solid cheesy matter in the infra-orbital cavity became softened and semi-liquid. The surrounding membrane had changed into a red granulation tumour, which was full of vessels and projected into the cavity. It was lumpy, very soft, and contained in its depths an epithelial layer which grew toward the outside. The conchae of the nose may have been altogether absorbed under pressure of the solid cheesy mass.

The inflamed conjunctiva behaved like the mucous membrane of the nose, except that pseudo-membranes were more frequently formed on them. In the submucous tissue of the eye-lids, which had been seriously infiltrated at

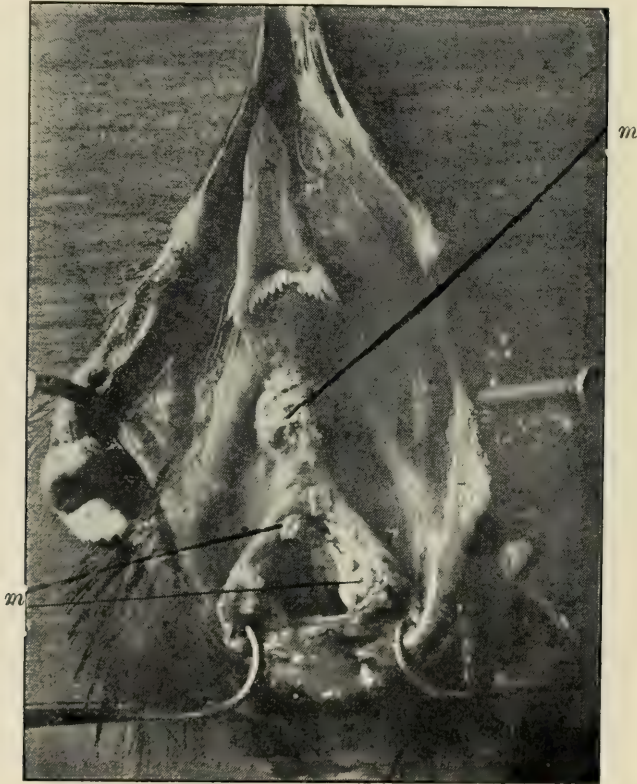


Fig. 10.—Fowl 46 ; throat and bottom of the mouth with false membranes (*m*), 14 days after inoculation with *B. pyocyaneus*.

the beginning, small, grey bodies of matter were found; these grew large, united and finally became compact, cheese-like yellow-white tumors. The surrounding tissue was sharply separated from these by a greyish-brown, smooth, pyogenous membrane, 1-3 m.m. thick. Usually the pseudo-membranes of the conjunctiva which at first were easily detached, were later firmly fastened to the cheesy masses in the depths of the lids. The firm, cheese-like masses in the lids showed no inclination to become soft, or to perforate the skin, like those formed in other places. On the inner and exterior sides of the lid of infected fowl 35, pseudo-membranes were formed, which had grown fast to one another. Similarly, the whole cornea of fowl 11 and inoculated pigeon 16 were

changed to a diphtheritic membrane. If putrid panophthalmia appeared, the bulbus oculi shrank; the corpus vitreum became grey with pus, and partially softened; and the retina was in shreds.

In birds that were suffering clinically from pneumonic dispnoea, and often in those that had not shown any symptoms of disease of the lungs, the post-mortem examination revealed extended pneumonic patches.

In the region of this inflammation, the branches of tracheae were stopped with firm, yellowish-white masses of exudation. Often in the centre of the pneumonic region, a mass of cheesy matter (from 1-2 cubic centimetres in size) was found connected with the masses in the branches of the trachea. These masses of cheesy matter were separated from the lung tissues by a brownish-



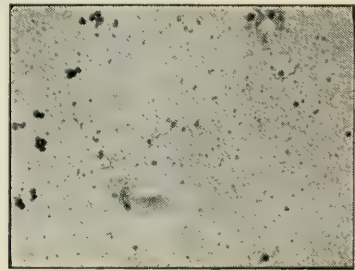
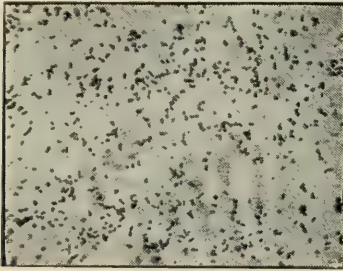
Fig. 11.—Head of hen 35, 8 days after inoculation with a culture of the Roup bacillus. *a*. Cheesy matter projecting from between the soiled and featherless eyelids. Nostrils are closed by a crust of dried secretion.

red granular membrane. The more peripheral parts of the diseased lungs were usually normal, or oedematous. The changes in the lungs were often accompanied by cheesy exudations into the pleural folds between heart and lungs. These grew to 3 cm. in length and were often 1 cm. in thickness and breadth. They were always covered by pleura. The latter, however, changed to a brownish, pyogenous membrane, from 1-5 millimetres thick. It was smooth on the outside, but the side, turned towards the exudation, was somewhat uneven, and covered with gray pus. Twice in the pericardium (diseased fowls 6 and 18) a somewhat grey, serous-purulent exudation was present. The pericardium and epicardium were gray. Firm, cheese-like exudation masses were often met with in the folds of the mesentery, between the intestines, gizzard and stomach. In fowls 4 and 18, the mucous membranes of the intestines were haemorrhagically inflamed.

The heart blood was always well coagulated, the spleen small and normal, the liver normal or enlarged, with fatty degeneration.

CROUPOUS AND DIPHTHERITIC MEMBRANES

Croupous and Diphtheritic Membranes. The pathologic anatomical conditions of the pseudo-membranes in mouth, eyes, etc., varied considerably. The small, grey, thin pellicles, which are often the first stage of the membranes, were found to be the outer epithelial-layers mingled with leucocytes. Sections of the epithelial-layers showed these to be more or less invaded by leucocytes, while the submucous tissue usually seemed intact. In all more severe cases, however, the loose, submucous tissue was completely filled up with leucocytes. The epithelial layer underwent changes, especially in the middle layer. The epithelial cells were dislodged from their normal position by fibrinous putrid exudation (Fig. 2). They lost their contour, and the protoplasm became



Figs. 12 and 13.—The Roup bacillus (*B. coccosmus*) magnified about 850. The bacillus is stained with gentian violet, the flagella by Van Ermegem's method.

cloudy or decayed to a granular detritus. The cell-nuclei swelled till they became two to six times their normal size, and the contents of the nuclei became homogenous and were difficult to stain, except one or two round, central or excentric nucleoli.

Often, too, the plasm of the nucleus became a fine granular detritus. These granules could then be deeply stained. The abnormal nuclei remained round and sharply outlined by thin nuclear membranes. They appeared like foreign bodies, and have usually been pronounced to be protozoa. Fig 3 shows these transformed nuclei, in which the edges of the separate cells have completely vanished and changed to a partly granular, partly turbid, decayed mass. In these cells there were a few nuclei of normal size; (a) the greater number, however, were swollen in varying degrees, with one or two well stained nucleoli; (b) the contents of the swollen nuclei, when freshly examined, were found to be homogeneous (see Fig. 6); but in Fig. 3, they appear granular, which is due to the treatment of the section while hardening was going on. In (c) we see leucocytes; at (d), two bacteria. The swollen epithelial nuclei are also distinctly visible in the markedly changed middle epithelial layers of Fig. 2 (c).

The swelling might be caused by the simple coagulation of the protoplasm, following death; or there was a mucous or colloidal degeneration. The latter was so much the more probable, as changed nuclei were found in the gelatinous

mucous masses in the eye and in the glanular canals. A certain interchange, therefore, seemed to exist between the two. The transformed nuclei were fairly resistant, which might be due to the condition of the nuclear membranes, for, while the cells themselves decayed, the nuclei lasted for a long time. They were constantly found in all more severe cases of pseudo-membranes. Transformed nuclei might be seen in the slimy-putrid secretions of mucous membranes, in the cheese-like exudations in the nostrils, eyes, bronchial tubes, lungs, pleural and peritoneal folds ; or, in other words, wherever there were epithelial or endothelial cells. They were not found in the solid masses of matter in the lids and in other submucous or subcutaneous tissue.

In the above-mentioned jelly-like exudations, the products in the eyes of fowls 35, 36, etc., the epithelial nuclei were greatly swollen. They were homogeneous, clear, with or without nucleoli.

While the changes described in the middle epithelial layer were taking place, compact masses of pus were deposited over this layer and the pseudo-membranes were thus formed. All membranes which could be easily removed became separated from the region of the middle epithelial layer (Fig. 1). We then had typical croup membranes and a regeneration of the epithelium took place from the lower layers. In those cases in which the membranes were firmly attached, even the lowest epithelial layers were very much altered. They were swollen and loosened by fibrous purulent exudations. Under the lasting invasions of the leucocytes, the constituents of the epithelium were lost. The compact mass of epithelial pseudo-membrane advanced towards the lower layer of the epithelium, and finally reached the submucous tissue and thus became a typical diphtheritic membrane.

Submucous glands were often partly, or altogether filled with leucocytes. In typical diphtheritic membranes small quantities of fibrous exudation were found especially in the region of groups of bacteria. The croup-membranes, the cheese-like bodies in nostrils and eye-lids, in bronchii, pleura and peritoneum, as well as the firm masses in the different tumors of the head, were made up of leucocytes, granular detritus, of bacteria and eventually, of a remnant of epithelium and foreign bodies.

BODIES RESEMBLING PROTOZOA.

When the secretions and exudations of birds affected with roup contained remains of epithelium, the round, protozoa-like epithelial nuclei, referred to above, were present. Besides these, other very different bodies, which often more or less resembled the protozoa described as the cause of fowl diphtheria, or epithelioma contagiosum, were seen. No case of epithelioma contagiosum came under our observation. Table 1 shows some of the protozoa-like bodies found. These figures were drawn from fresh preparations which had been stained either with methylene blue, gentian violet, fuchsin, or Lugol's solution. The material was quite fresh, or had been stained without drying or heating. Many peculiarities could be distinguished with the methylene blue or Lugol's solution. The commonest forms of protozoa-like bodies were the swollen epithelial nuclei, which have been more minutely described above. They were

always most numerous on the outside of the cheese-like matter in nostrils, eyes, and bronchial tubes, as well as on the underside of the pseudo-membrane or in the material which was scraped from the mucous membrane. The other protozoa-like bodies were present in the greatest numbers in material from the same source. If we compare the drawings of the different bodies in (Figs. 14-25), we find very many forms which agree with the protozoa found by Rivolta Silvestrini, Magganti, Piana, Pfeiffer, Babes, Puscariu, and Galli-Valerio

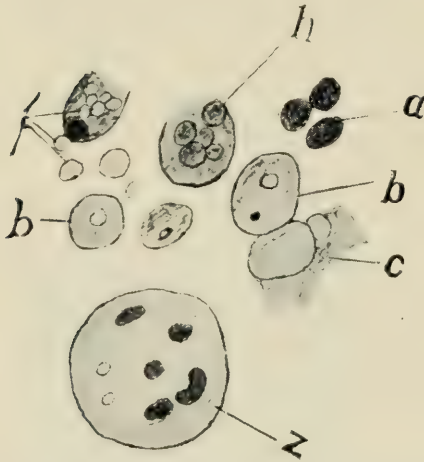


Fig. 14.—Protozoa-like bodies from the bronchial exudate of pigeon No. 4. *a* The nuclei of leucocytes. *b* Swollen epithelial nuclei with or without nucleoli. *f* Fat droplets. *h* Yeast cell with spores. *z* Probably a giant cell. Epithelial nuclei have a diameter of 8-10 μ , the other bodies are drawn on the same scale.

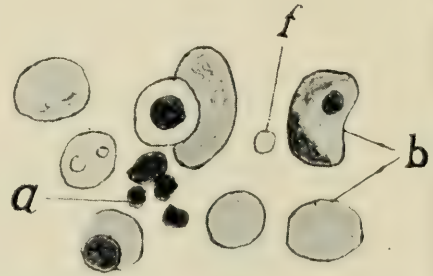


Fig. 15.—Bodies from the slimy purulent nasal secretion of pigeon No. 12. Same lettering as figure 14.

Round, amoeba and crescent-shaped forms, etc., were often present and the contents of these bodies were homogeneous, granular, or partly homogeneous and partly granular. They stained either badly, or not at all. Very often, one or more nucleoli were present which appeared in unstained preparations as clear or reddish spots. In stained preparations, the one small nucleolus was often stained, while the other in the same cell had not taken the stain at all. Besides these central bodies, the protozoa-like forms often held enclosed larger clear vacuoles, which could be stained black with osmic acid, and were, therefore, fat globules. Other similar globules as they appeared in pigeon 4, when 7 gave no fat reaction and might have been true protozoa, but were more probably yeast-cells. Such accidental existence of foreign bodies in the exudations is not a rare thing, as is shown by Figs. 18, 19, 22 and 23. Very many of the protozoa-like bodies were either enclosed in the remains of cells, or showed debris of cells that had been present.

Twice, motile protozoa were present. In the bronchial tubes of infected hen No. 41, there were some oval forms which moved by means of a wreath of short cilia around the head end. (*Infusorium diploëdium* (See Fig. 22, i).

On the surface of the firm exudations in the mouth of pigeon 6, round granular forms, each with three long cilia, were present. There is nothing remarkable in this, for motile protozoa were frequently found in the mouth cavity and intestines of perfectly healthy fowl.

Kitt describes and gives drawings of protozoa, or "Molluscum-Koeper," as he describes them. They are irregular bodies which stain intensively, and were found in the cells of an epithelioma.

We observed the same bodies in the epithelial cells under the pseudo-membrane in the mouth of fowl 28, and they are shown in Fig. 5. Unstained, they were homogeneous, clear and greenish in color. They were stained dark blue with haemotoxylin. In those parts of the epithelium in which these bodies were absent, the cell nuclei were homogeneous, or finely granular, and very much swollen. The clinical form of this case of the disease was striking because the membrane always formed again with extraordinary obstinacy, and in some cases grew right into the bone tissue of the left lower jaw. Similar bodies were present in the exudation of bird 26, and inoculated fowl 29.



Fig. 16.—From the eyelid of fowl No. 29 structures resembling Kitt's "Molluscum bodies."

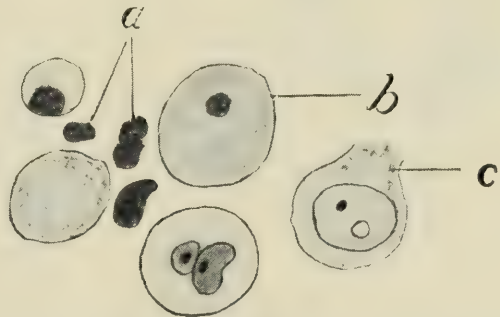


Fig. 17.—From the secretion and exudation from the eyelids of hens u 35, 36 and 39. Swollen epithelial nuclei are 16 u in diameter.

As appears from the drawings, the most varied protozoa-like bodies were present in the secretions and exudations, of naturally diseased fowls and of those inoculated with bacterial cultures.

In conclusion, we may state that most of the above described bodies were probably different products of degeneration of the epithelium and endothelium. Some must be regarded as foreign bodies and protozoa accidentally present in the exudations.

Kitt's molluscum bodies, in the epithelium of fowl 28, resemble the cell enclosures frequently found in Carcinoma, which are claimed by some as being the causal organism.

BACTERIA.

In all the pathological exudations and secretions, bacteria were present. Cultures in gelatine and agar plates and aerobic and anaerobic cultures in bouillon were usually made. In some cases, the material was only examined microscopically. In six cases of diseased fowls (29, 30, 33, 34, 35 and 36), *B. pyocyaneus* in pure cultures grew from spleen, liver, kidneys and blood. In all other cases, either some colonies of *B. coli* grew from cultures made from these organs, or the cultures remained sterile.

From the exudations and secretions, many different micro-organisms developed, and occasionally, yeasts and fungi were present. The colon bacillus

was sometimes isolated, and a large number of other bacteria-cocci, bacilli and a spirillum. The spirillum which had three or four turns could not be grown in any culture medium. Some five or six of the other micro-organisms were grown in pure-cultures, and their pathogenic properties were investigated by inoculations into guinea pigs, mice, and chickens. No results followed these inoculations; and, consequently, we must regard these forms as purely adventive.

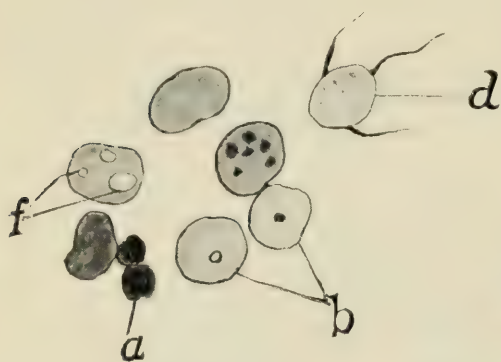


Fig. 18.—From the cheese-like exudate from the *cella infraorbitalis* of pigeon 6. *d.* Is one of the Flagellata with three motile flagella.

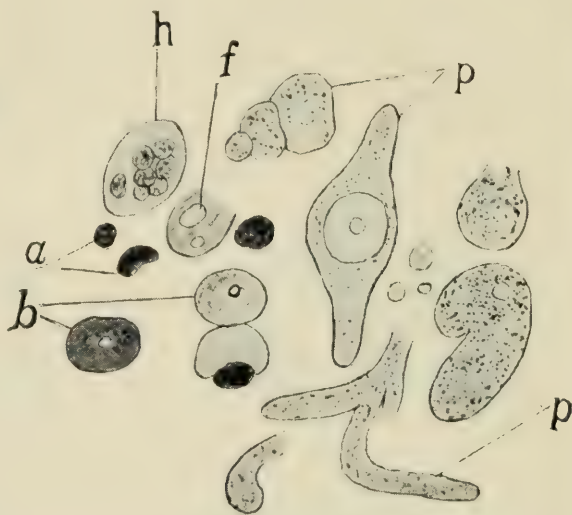


Fig. 19.—From the underside of a diphtheritic membrane from hen No. 7. *p.* Probably some form of vegetable life.

We succeeded, however, in isolating two virulent forms of bacteria. The one was a typical *Bacillus pyocyaneus*. This bacillus was present in the cheese-like masses in the lungs of hen 9, in company with a few *B. coli*; in the firm exudations of the *Cella infra-orbitalis* of hen 32; in the cheesy masses of hens 29, 30, 31, 33, 34, 35, 36. In the six cases last mentioned, the bacillus was also isolated from the blood, liver, kidneys and spleen. Five of these birds were killed and had been dissected at once.

This *Bacillus pyocyaneus* was, as the inoculation experiments show, capable of producing typical croupous and diphtheritic membranes in mouth and eyes; it was the cause of severe tumors in the submucous, or subcutaneous tissue, the contents of which were firm, cheesy and yellowish-white. It produced purulent conjunctivitis; blindness; purulent panophthalmia; inflammation of the lungs; and hard cheese-like exudations in the bronchial tubes. In a word, it produced symptoms identical with those of roup.

The second virulent form of bacteria isolated seems to be a new organism. We have named it *B. cacosmus* and shall also refer to it as the roup bacillus. It was in great numbers in the croupous membranes under the tongue of hens 1 and 9; in the cheesy material of the tumor on the head of hen 5, as well as in the purulent conjunctival secretion; in the nasal secretion of hen 4; in the purulent masses which closed the lacrymal duct of hen 21; and was also found in a number of other birds affected with roup.

Further, this bacillus was repeatedly isolated from the secretions of the hens and pigeons which had been inoculated with it. At first, it was usually present in the tumors of the submucous or subcutaneous tissue in pure culture. Later, it was found mixed with other bacterial forms in the tissues and also in the exudation products. In chronic cases of the disease, the roup bacillus could not be culturally detected, but it could often be identified microscopically in the cheese-like masses of diseased or inoculated fowls. We have never isolated this bacillus from the blood or other internal organs.

MORPHOLOGY OF *B. CACOSMUS*.

The roup bacillus is a small rod .25 to 5m.m.m. thick, .25 to 5m.m.m. long, with rounded ends. It often occurs in pairs and occasionally in short chains of 4 or 5 cells. The smallest forms are coccus-like, the longer are rods. With the ordinary aniline stains, they stain very well. In old bacilli, there are often only zones or parts of the cell that take the stain (involution forms). The bacteria are not stained by Gram's method. In young agar or bouillon cultures, the roup bacilli are very motile. They possess 4 or 5 peritrichous cilia which are three or four times as long as the bacilli. Capsules and spores are not formed.

CULTURES.

Gelatine Plate Cultures. Colonies appear in 24-28 hours as small, round, iridescent points, which grow slowly. They are flat, round, or somewhat irregular in shape. They never become prominent; but, as their growth continues,

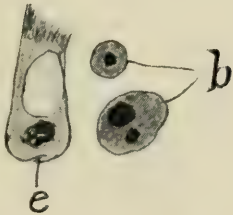


Fig. 20.—From the nasal secretion of hen 11 and 26. Ciliated cell showing slimy degeneration.

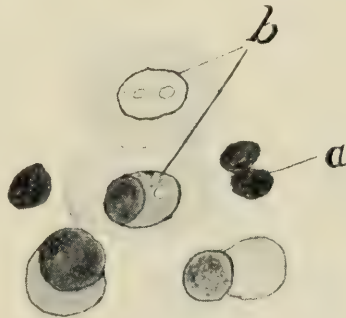


Fig. 21.—Bodies from a tumor from hen No. 17.

they sink deeper into the gelatine. The surface is smooth and shining. They are light grey in color. Through the microscope, young colonies are seen to be slightly granular. The centre is dark, yellowish or brown, the border zone clearer, and usually provided with darker, radiate markings; in older colonies, these disappear, and the gelatine becomes liquefied to the bottom of the plate. The growth at the edge of the colony lasts for about 8 days, and then ceases. In this time, they usually reach the size of from 3-5 mm., while after two days they were from 1-2 mm. in size. The submerged colonies appear as round, slightly granular, clear points, which quickly penetrate to the surface of the gelatine.

Gelatine Streak Cultures. Along the needle track, a thin, grey, shining growth appears, under which the gelatine soon becomes furrowed. The groove sinks deeper into the gelatine, and the liquefied gelatine and the bacteria flow as a turbid mass to the bottom of the tube.

Gelatine Stick Cultures. After 24-28 hours, a homogeneous, fine, grey band forms along the line of puncture. At the same time, on the surface of the gelatine, a smooth, fine covering grows, and, after two or three days, the gelatine becomes liquefied slowly around the puncture, spreads gradually over the whole surface of the gelatine, and then the liquefaction becomes stratiform. The liquefied gelatine is turbid, but never ropy. On the surface of the solid gelatine, a copious grey sediment settles. After two or three weeks, when about 2-3 of the gelatine has become liquefied, growth ceases. The liquid mass gives a very strong alkaline reaction, and has a very disagreeable putrid smell.

Agar Plate Cultures. At 37 degrees C., in 24 hours the surface colonies appear as smooth, gleaming points, which grow quickly into round or irregular shaped masses. The centre becomes somewhat thicker and greyer. After two days, they are three to five mm. in diameter. The whole colony has an iridescent lustre. Deep colonies appear as grey points. Seen through the microscope, they are round, or somewhat irregular, clear, and darker at the margin.

Agar Streak Cultures. The culture spreads over the whole surface, and forms a smooth, faintly gleaming, thin, grey cover, which appears blue when the light falls on it. The condensation water becomes turbid and grey. On

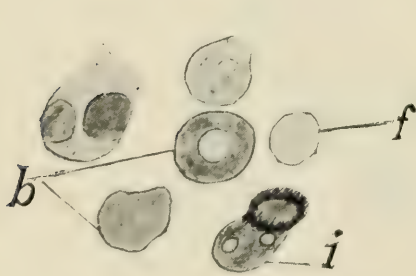


Fig. 22.—From the bronchial exudate No. 16.
i. A motile infusorium with ciliated crown.

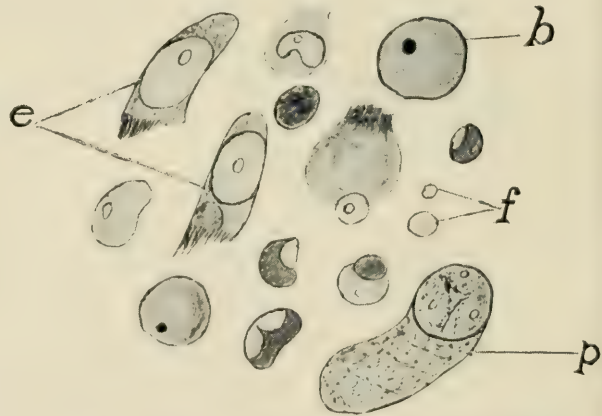


Fig. 23.—Bodies from the slimy pus from the *Regio olfactoria*, or hen No. 23. e. Ciliated cells with swollen nuclei. p. A foreign body, perhaps of vegetable origin.

agar, with 5 per cent. glycerine, the growth is the same, only much slower.

Bouillon Cultures. In 24 hours, the bouillon is uniformly turbid. The reaction is unchanged, and a grey sediment forms which diffuses uniform when the test-tube is shaken. After 4 or 5 days, a thin, grey pellicle appear

on the surface, which is easily broken and then sinks in shreds to the bottom of the tube. The culture has a very disagreeable, sweetish odor. Old cultures are always very alkaline. Very old cultures become completely sedimented, and brown in color. Growth occurs in slightly alkaline or acid bouillon, and small lumps appear in the sediment.

Milk Cultures. In four days, the milk coagulates into a soft curd with a thin layer of turbid, yellowish-grey serum on the surface. The reaction is slightly alkaline, and the curd digests slowly, as it takes about four weeks for the curd to completely dissolve. The liquid is turbid, yellowish-grey in color somewhat thick, and with an alkaline reaction. There is usually a thick, greyish-white sediment. The culture has a disagreeable odor.

On Potatoes, the roup bacillus develops fairly well, as a thin, grey, smooth and shiny layer.

In Dunham's solution, a uniform turbidity appears. At the bottom, a grey, flocky sediment forms. After three or four weeks the culture is dark brown, very alkaline, and has a putrid odor.

1 per cent. solution of Peptone with 4 per cent. Dextrose. In this medium, a copious, diffuse turbidity forms, as well as a granular sediment. 14 per cent. of gas collects in 48 hours. The reaction is slightly acid, and remains so.

Temperature relations. The roup bacillus grows best at a temperature of 37-40 degrees C., and it also grows well at room temperatures, 20-22 degrees C.

The thermal death-point (Sternberg's method) is 65 degrees C. for 10 minutes.

Oxygen requirements. It grows best aerobically. Anaerobic cultures are poor, and grow very slowly.

Relation to sunlight and dessication. An exposure of 2 hours to direct sunlight (Lat. 42) kills the bacillus exposed in agar dish cultures. It succumbs to dessication in 6 days.

Action of disinfectants. The disinfecting power of the following chemicals was :

Corrosive sublimate, 1 per cent....	10-15 seconds.
Lysol, 2 per cent. ...	1½-2 minutes.
Carbolic acid, 5 per cent. ...	12-15 seconds.
Creolin and glycerine, equal part. 5 c.c. in 100 c.c. water	
(Friedberger-Froehner).....	1-2 minutes.
Lime water (Sat. solution) ...	10-15 minutes.

VIRULENCE.

The virulence of the roup bacillus was at first weak, but was much increased by passing once or twice through pigeons. Like *B. pyocyaneus*, the roup bacillus produced suppuration, but the effect was strictly local.

Pathogenesis. Rabbits die after an intraperitoneal inoculation of 1 c.c.

of a young bouillon culture in from 18 to 24 hours. Dissection shows a widespread, purulent peritonitis, with slight bloody extravasations of the peritoneum. Subcutaneous inoculations of small quantities of bouillon cultures lead to hot tumors, which spread quickly and in which firm, hard centres form. The whole tumor gradually assumes the same hard, uneven condition. The skin becomes dry, cracks, splits and forms a brown, thick crust which, after some time, falls off. Under the crust, there is an extensive, uneven yellowish-white, cheese-like mass, 2 mm. to 2 cm. thick, firmly adherent to the underlying tissue. Gradually this mass falls off, and regeneration of the tissue from the edges of the skin follows. The hard, cheese-like masses look exactly like the croup and diphtheritic membranes of fowls and pigeons. They consist

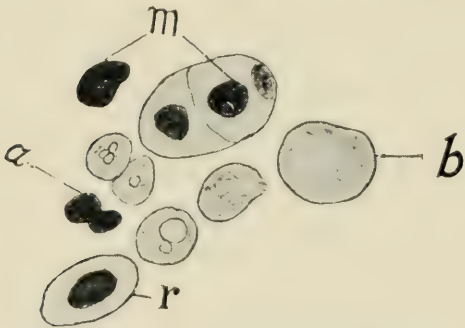


Fig. 24.—From the nasal secretion of hen No. 6. *m.* Kitt's "Molluscum bodies." *r.* A red blood cell.

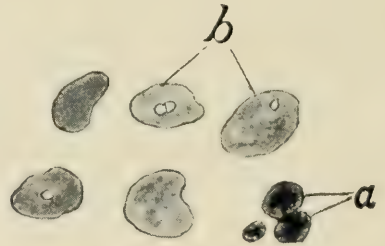


Fig. 25.—Bodies from the under side of a false membrane from pigeon No. 11.

of bacteria and leucocytes, as well as of some detritus. The general conditions of the rabbits is poor, so long as there is a hot tumor. Later, their condition improves, though the animals remain very thin in spite of being well fed. In a few cases, sympathetic inflammation of the eyes, purulent conjunctivitis on one or both sides, purulent panophthalmia, perforation of the cornea, etc., occur during the course of the healing of the local lesions. If there are no complications, the local lesions heal in from 3-5 weeks; if the described complications set in, death comes after the disease has run its course for 1-3 months.

Old cultures filtered through Chamberland filters, produced, when inoculated intraperitoneally, neither death nor sickness.

Guinea Pigs. The effect of the roup bacillus was the same on these animals as on the rabbits.

Mice die in 12 to 18 hours from inoculation with 1-8 to 1-4 c.c. of a bouillon culture of the bacillus. Dissection shows excessive swelling of the spleen. Intraperitoneal inoculation gives rise to hemorrhagic purulent peritonitis. The bacilli are present in great numbers in the exudations and spleen; whilst they are but seldom found in the blood.

The effect of the roup bacillus on hens and pigeons, is shown in the following table of inoculation experiments.

TABLE OF THE NATURAL CASES OF THE DISEASE.

Number.	Slimy, putrid conjunctivitis with or without a soft swelling of the lids.	Pseudo membranes on the conjunctiva or cornea.	Phlegmonous swelling of the lids with hard putrid centre.	Diseases of the inner eye.	Submucous or subcutaneous tumors with solid putrid centre.	Slimy putrid catarrh of the nose and the secondary cavities of the nose.	Pseudo membranes in mouth and pharynx.	Pneumonia with or without exudations in the bronchial tubes, etc;	Affection of the pleura and peritoneum.	Catarrh and inflammation of the bowels.	Chronic course of the disease. x — Acute	Condition : Thin x — Good	Recovered Died o Killed x —
1	x	...	x	...	x	x	x	x	x	...	x	x	x
2	x	...	...	...	...	x	...	...	...	...	x	x	o
3	...	...	...	...	...	x	...	...	...	x	x	x	x
4	x	...	x	x	...	x	...	...	x	x	x	x	x
5	x	...	x	...	x	x	x	...	...	...	x	x	x
6	x	...	x	...	...	x	x	x	x	...	x	x	x
7	...	...	...	...	...	x	x	...	...	...	x	—	—
8	...	...	...	...	...	x	x	...	...	...	x	—	o
9	...	...	...	...	...	x	x	...	x	...	—	—	x
10	...	...	...	...	x	x	x	...	...	...	x	—	x
11	x	x	x	x	...	x	x	...	...	...	x	—	x
12	x	x	...	...	...	x	x	x	x	...	x	x	x
13	x	x	...	...	...	...	x	x	x	x	x	x	x
14	...	...	...	...	x	x	x	...	...	...	x	—	—
15	x	...	...	...	...	x	...	...	...	...	x	—	—
16	x	x	x	...	x	x	x	...	...	...	x	x	—
17	x	x	x	..	x	x	x	...	...	...	x	—	x
18	...	...	...	...	...	...	x	x	x	x	x	—	x
19	...	...	...	...	...	...	x	x	x	...	x	x	x
20	...	...	...	...	...	x	...	...	...	...	x	x	o
21	x	...	...	...	...	x	x	...	...	...	x	—	—
22	...	...	...	...	...	x	...	...	...	...	x	x	x
23	x	...	x	...	...	x	...	...	...	...	x	—	—
24	x	x	x	x	x	x	...	...	...	...	x	x	—
25	x	...	x	...	...	x	...	...	...	...	x	x	x
26	x	...	x	...	...	...	x	...	...	...	x	—	—
27	x	...	x	...	...	...	x	...	...	...	x	x	—
28	...	...	...	...	...	...	x	x	...	...	x	—	—
29	...	...	...	...	...	x	...	...	...	...	x	—	—
30	x	...	x	...	...	...	x	...	...	...	x	x	—
31	...	...	...	...	...	...	x	...	...	...	x	—	—
32	x	...	x	...	x	x	x	x	x	...	x	x	x
33	x	...	x	x	...	x	...	...	...	...	x	x	—
34	...	...	...	...	...	x	x	...	...	...	x	x	—
35	x	...	x	x	...	x	x	x	...	...	x	x	x
36	...	...	...	...	...	x	x	...	...	...	x	—	—

EXPERIMENTS ON INFECTING CHICKENS AND PIGEONS.

Fowl Diphtheria or Roup, prevalent in America, appears and passes for an infectious disease, because we find that from twenty to ninety per cent. of all chickens in a flock may become diseased. It is, therefore, of great importance to know how infection takes place, and how the disease is transferred from bird to bird. In order to orient our observations with what has already been noted by others, it will be necessary to briefly summarize a portion of the literature which has appeared.

Zurn says that diphtheria is a highly infectious disease. He claims that secretion and exudation products of diseased birds are probable carriers of the poison, but he did not support this statement with experiments.

According to the statements of Siedamgrotsky, Friedberger and Perroncito, it is impossible, or very difficult, to infect healthy birds with the pathological products of ropy ones. Cornevin and Nicati, on the other hand, inoculated the pathological secretions of diseased birds into healthy chickens and rabbits, and produced diphtheria in these animals. According to Trinchard, it is easy to infect healthy birds, the time elapsing from the date of infection to the first symptoms of the disease being 7-20 days.

Babes and Puscariu were not able to produce the disease with diphtheritic membranes, containing bacteria and numerous trichomonas.

Massanti transferred the disease with fresh pseudo-membranes containing many flagellata. When he killed these protozoa with salt, he never succeeded in producing the disease. Loir and Ducloux infected healthy birds with the blood and any of the parts of organs from diseased ones. Kitt states that a transfer of croupous-diphtheritic membrane to healthy birds very frequently produces no infection. Friedberger and Froehner declare that diphtheria caused by protozoa can more easily be transferred to healthy fowls than diphtheria produced by bacteria.

Moore tried to infect healthy chickens with pathological secretions and exudations, and kept healthy fowls in with diseased ones; but in no case was he able to produce the disease.

In the following experiments, the diseased birds were obtained from the poultry department of the Ontario Agricultural College. Most of the healthy ones were purchased from different farms where no roup was present, but a few were secured from the Poultry Department where they had been exposed to infection, but had never become affected.

EXPERIMENTS TO ASCERTAIN IF HEALTHY BIRDS BECOME AFFECTED WHEN KEPT WITH DISEASED ONES.

Fowl No. 1. Small hen about 6 months old, in fair condition. To irritate the conjunctiva, a few drops of 2 per cent. acetic acid were dropped under the left eye-lid. Then the hen was placed in the cage with diseased chickens No. 1-5. 3 Dec. 01.

Dec. 9.—General conditions unchanged. From the left nostril a little serous fluid escapes, when one presses on the dorsal wall of the nose, more of this secretion exudes from the nostril.

Dec. 13.—The left nostril is closed entirely with dirty looking crusts of dried up secretion, mixed with food particles. Under this crust is a small quantity of a grey, sticky and putrid-stinking liquid.

Dec. 18.—Very copious stinking secretion runs from the left nostril. General condition disturbed. The bird generally stands at the back corner of the cage, in a crouching position, the head drawn close to the body and very often tucked under the wing. Eyes often kept shut, and the beak generally a little open.

Dec. 19.—Discharge from both nostrils. Nasal secretion is slimy and putrid.

Jan. 3, 1902.—Hen has lost very much flesh. All visible mucous membranes are pale. General condition occasionally normal, but generally greatly depressed. Appetite always fair. On the mucous membrane in the mouth is some sticky slime, and on both sides near the tongue there are two small greyish-white pseudo-membranes about 1 mm. thick. They can be easily removed. The mucous membrane under them is uneven, red and begins to bleed at various spots.

Jan. 8.—Pseudo-membranes have disappeared from the mouth. The left nostril is entirely closed by a dry, yellowish-white, cheesy mass, which can only be removed with difficulty, when the surface underneath bleeds. This diseased part was treated with a 2½ per cent. solution of Creolin.

Jan. 9.—At the place treated with Creolin yesterday, a new pseudo-membrane has formed. Treatment again renewed.

Jan. 11.—The left nostril again blocked up by the cheesy yellowish mass. In many places in the mouth, thin, grey pseudo-membranes and at two places on the left side of the mouth yellowish-white patches of croup-membranes have formed.

Jan. 14.—Both nostrils are free from any secretions, but the disagreeable smell continues. At several places in the mouth, small pseudo-membranes may be seen. General condition, fairly good.

From 15th of Jan. to 3rd of Feb.—Chronic catarrh of both nostrils, sometimes with serous, and at other times with much pus. From time to time, the discharge from the nostrils may stop for one or a few days. There is always a very bad smell present. Very often pseudo-membranes appear in the mouth, especially on both sides near the tongue, around the entrance into the larynx, or on the palate, etc., for one or a few days. They never grow larger than 1-4 cm. The general condition was always disturbed, sometimes more, sometimes less, with loss of flesh and anaemia.

Feb. 3.—Killed with chloroform.

Post-Mortem : Thin carcass.

Conjunctiva and mucous membrane of the mouth very pale, without pseudo-membranes. Nostrils are filled with dirty grey dried secretion. The mucous membrane in the regio olfactoria is very soft, red and swollen. It shows at several places, small, bloody extravasations. It is covered with a grey, slimy mass mingled with pus and bloody streaks. The lower parts of the nasal canals are blocked up with a mass, consisting of putrid slime, and solid granules of solid white pus. The whole mucous membrane and submucous tissues have disappeared. The cartilage of the left oral concha is at several places black, dry and necrotic, or grey with very bad smell. In the dorsal wall of the pharynx and the mucous membrane of the higher third of the oesophagus are very many lymphoid follicles, swollen and filled with a yellow cheesy matter. They extend often as deep as the muscles and consist of pus corpuscles and four different kinds of germs (short thick rods, single or generally two together ; long chains of another germ ; streptococci and staphylococci). The

organs are normal ; spleen and liver small. Cultures from these two organs remain sterile. The putrid slime from the nostrils consists microscopically of slimy masses, desquamated epithelial cells, pus, erythrocytes and very many spirilla. A large coccus, several *B. coli* and *aerogenes* bacilli, and the roup bacillus in a few specimens, were isolated.

Fowl No. 2. Healthy cock, about one year old. 13th Dec. '01. Was kept in the same cage with fowl No. 1, and the diseased chickens 1-5.

Dec. 21.—General condition normal. At the right nostril, a small quantity of a clear serous fluid is visible.

Dec. 26.—The right nostril is entirely closed with thick grey, crusty secretion. On taking this away, large quantities of a grey, putrid, stinking slime exude from the nostril.

From Dec. 27 to January 10 there occurred chronic nasal catarrh ; sometimes discharging and at other times stopping. Offensive smell from nose and mouth. General condition not much altered ; appetite good. No pathological changes were observed on the mucous membranes in the eyes and mouth.

Jan. 29.—For eight days, the bird showed neither nasal catarrh nor any other abnormal appearance. Killed by decapitation.

Post-Mortem : Fairly well nourished carcass. In the nasal parts of the right ductus lacrimalis are some small, brown spots, encased in the mucosa.

Fowl No. 5. Large, strong, well-developed hen, about 1 year old. It was kept in a cage with infested fowl 4 for ten days.

Jan. 10.—Both nostrils are partly closed by a clear, serous slimy, fetid-smelling liquid. Mucous membranes very pale. General condition and appetite, normal.

Jan. 14.—At the entrance to the larynx, and on the dorsal wall of the larynx itself, a pseudo-membrane is located. It has an uneven surface, is yellowish-white in color, 1 to 2 mm. thick, and can be removed with little difficulty. The undersurface after removal begins to bleed at several spots.

Jan. 15.—At the place where the pseudo-membrane was removed, the mucous membrane is apparently normal. Discharge from the nostril almost entirely stopped.

From the 16th of January to the 4th of May chronic nasal catarrh of both nostrils, with fluctuating severity, occurred. Often the mucous membrane in the mouth had for one or several days small pseudo-membranes. General condition was abnormal during the later stages of the disease, with sleepiness, diminished appetite, and all visible mucous membrane pale. Chronic anaemia set in, as a secondary disease, following the roup.

Fowls Nos. 10 and 11 were healthy hens, about one year old. They were kept with the diseased chickens the second half of the month of December 1901, and the whole month of January, 1902. General condition remained unchanged. Eyes and nostrils remained normal. Several times on the mucous membranes in the mouth, small croupous membranes appeared for one or two days ; then they disappeared again. The mucous membrane was pale, and was sometimes covered with a sticky slime.

Feb. 6th and 7th.—Left nostril of hen No. 10 shows a small quantity of serous, odorless fluid, which had disappeared the next day. These two hens remained normal and healthy.

Fowls No. 6, a., b., c., d., and e., were kept with the diseased chickens during the month of December, 1901, and January, 1902, without becoming infected. Later these chickens were used for experimenting with the roup bacillus, which had been made virulent by passage through pigeons. All reacted with typical symptoms of chicken diphtheria.

EXPERIMENTS TO SHOW IF HEALTHY BIRDS COULD BE INFECTED WITH SECRETION OR EXUDATIONS OF DISEASED ONES.

Fowl No. 4. Young, healthy hen. 17th Dec., 1901. Some of the solid, cheesy peritoneal exudation from diseased fowl No. 4, was rubbed on the sound or slightly scratched membranes (mucous) of both eyes, the mouth, and in the higher parts of the nostrils.

Jan. 18.—General condition normal. At the small scratch wound in the mouth the membrane is slightly swollen and red. A little clear, serous fluid exudes from the right nostril.

Jan. 19.—Mouth normal. Both nostrils are moist, with a little serous liquid having no smell.

Jan. 21.—The secretion from the nostril is grey, slimy and has a putrid smell. On the mucous membrane of the right side of the mouth, an irregular yellowish-white spot is located. It is about 1 m.m. thick and 1-2 cm. in size. This patch was taken off, and the membrane under it bled at a few spots.

Jan. 14.—Chronic, putrid nasal catarrh. General condition unchanged. Mucous membrane in the mouth always very pale, sometimes with small pseudo-membranes.

Jan. 21.—In the middle of the palate, a pseudo-membrane is located, about $\frac{1}{4}$ cm. in size, and 1 to 1½ mm. thick. It was removed and rubbed on the left conjunctiva.

Jan. 22.—The membrane has reformed in the mouth. Eyes are normal.

Jan. 23.—Some new membranes have formed at different places in the mouth.

From the 27th of Jan. till the middle of March, the chronic nasal catarrh disappeared, after having ceased several times for only one or a few days. The local infection in the mouth disappeared at the same time. General condition was good.

Fowl No. 5a. Healthy hen, half year old. On the 17th of December, some of the putrid nasal secretion from diseased chicken No. 4 was rubbed in and upon the mucous of the eye and the regio olfactoria.

This hen never became sick or diseased.

Fowl No. 7. A hen like No. 5a was inoculated on Jan. 3rd, 1902, with nasal secretion and pseudo-membranes from fowl 5. Inoculation on and under the mucous membrane of the mouth, and on the mucosa of the regio olfact. No visible reaction followed.

Fowl No. 9. This fowl suffered from chronic diarrhoea. It was kept in the stable for four months and then inoculated in eye-lids, mouth, and nostrils with croupous material from the eye-lid of diseased chicken No. 11.

Fowl No. 8. Healthy cock, three years old. Had been kept in the stable continually for three months.

Jan. 4.—On the scratched mucous membrane in the mouth near the tongue, a croupous membrane from fowl 3 was rubbed in.

Jan. 5.—The mucous membrane at the place of infection was red, and covered with much saliva. General condition, normal.

Jan. 6.—At the place of infection, the mucous membrane is uneven grey; at several places, yellowish-white points appear.

Jan. 7.—Near the tongue, a croupous membrane has formed, yellowish-white in color, 1 mm. thick and about 1 cm. in area. The surrounding mucosa is reddened. After having taken off the membrane, the mucosa begins to bleed. At several other places in the mouth, very thin, greyish pseudo-membranes formed.

Jan. 8.—The pseudo-membrane near the tongue, which had been removed yesterday, has reformed, and is larger than before.

Jan. 15.—At the primary seat of infection, the croupous membranes have disappeared, but a small croupous patch is located on the left side of the mouth, and there are four others upon the mucous membrane of the palate, near the entrance to the nasal cavity.

From the 16th Jan. till the 25th Feb.—Often pseudo-membranes appeared on the mucous membranes in the mouth, and disappeared again in a few days. The general condition at this stage was poor. All visible mucous membranes were pale.

This fowl was killed and the post-mortem examination showed the existence of anaemia. No growths in cultures from the spleen.

Fowl No. 21. Young, healthy hen.

Jan. 3.—Was inoculated with slimy, putrid, nasal secretion from fowl No. 1, containing very many spirilla. $1\frac{1}{2}$ c.c. was injected into the mucosa and submucosa of the mouth and nose, $\frac{1}{2}$ c.c. into the right eye-lid and $\frac{1}{2}$ c.c. into the right pleural cavity.

Jan. 4.—General condition unchanged. Eye-lid slightly swollen and conjunctiva moist. On the palate, one pseudo-membranous patch has formed, $\frac{1}{4}$ cm. in size, yellowish-white and cheesy. Mucous membrane of the mouth is pale.

Jan. 7, and later.—General and local condition normal.

Fowl No. 24a.—This bird was inoculated the 23rd of January, 1902, with material taken from the cheesy, degenerate lymph follicles in the oesophagus of fowl No. 1.

Fowl No. 25.—This chicken was inoculated with a solid mass of yellowish pus taken from the eye-lid of diseased fowl No. 21.

In both cases, the eye-lids became swollen for a few days. The mouth remained unchanged, and the general condition was never disturbed.

Besides these experiments, we tried to infect six other chickens (6-12

months old) with pathological secretions and exudation products. Several times the eye-lids became swollen for a few days, but no typical roup disease could be produced.

These results show that out of 10 healthy chickens, kept with diseased ones, five became infected. In four cases, nasal catarrh appeared in from 6 days to 1½ months. In the same birds, pseudo-membranes sometimes appeared in the mouth for a few days. In fowl No. 10 only, they appeared without any changes in the nostrils. Five fowl did not take the disease at all, although they were exposed to the same infection.

Of the 14 chickens and 1 pigeon (see later) which we attempted to infect with secretions and exudations from diseased fowls, only two fowls (Nos. 4 and 8) became diseased with roup. These experiments show that chicken diphtheria, or roup, may be transferred.

EXPERIMENTS TO INFECT HEALTHY FOWLS WITH *BACILLUS CACOSMUS* (THE ROUP *BACILLUS*.)

Fowl No. 3. Small hen, weak constitution, about one year old.

Dec. 17.—The conjunctiva and the higher parts of the nasal mucosa were irritated with dilute lactic acid, after which a portion of a young agar culture of the roup germ (isolated from diseased hen 4) was rubbed in.

Dec. 18.—General condition unchanged. At the right nostril, some fluid can be seen.

Dec. 21.—At the right nostril, a small quantity of a slimy, putrid secretion is apparent. Disagreeable smell.

Jan. 8, 1902.—Typical chronic nasal catarrh is present. Mucosa of the mouth is pale. Under the tongue, an irregular croupous membrane is located, about 1 mm. thick. This membrane was difficult to remove, and after removal the surface beneath bled.

Jan. 9.—An extended new membrane has formed at the old place. It was again removed, and cultures were made from the mucous membrane lying beneath the false membrane, from which the roup germ was subsequently isolated.

Jan. 10 to Feb. 10.—Nasal catarrh remained chronic and putrid. The croupous membrane disappeared after having reappeared after four daily removals. Later, several small membranes appeared at different places in the mouth.

April 24.—The discharge from the nose has disappeared for 8 days, and there is no disagreeable smell. All visible mucous membranes are extraordinary pale. General condition, normal. No apparent loss of flesh during the disease.

Fowl No. 13. Healthy hen, about 8 months old.

Jan. 10, 1902.—½ c.c. of a bouillon culture, made from parts of the epithelial membrane under a removed croupous patch of diseased chicken 9, was subcutaneously inoculated. The culture was not pure, but the most numerous germ was the roup bacillus. At the place of inoculation, a hot tumor appeared, and became slowly resorbed in a few days.

Fowl No. 4. Weak hen, about $\frac{1}{2}$ year old.

Jan. 12.—Inoculated in the mouth with an anaerobic bouillon culture, 48 hours old, made with the same material from diseased chicken No. 9. It contained coli and roup bacilli, and a streptococcus.

Jan. 13.—At the place of infection in the mouth, two small white spots have formed.

From 14th of Jan. till 10th of Feb.—General condition, normal. Several times, small croupous spots formed on the mucous membrane in the mouth for a few days.

Fowl No. 18. Healthy young hen.

Jan. 12.—Was inoculated with an aerobic culture from diseased hen No. 9 in the mouth and under the right conjunctiva. This culture contained the roup bacillus, and some long and thick rods, and a few cocci.

Jan. 14.—The infected eye-lid is slightly swollen. Mouth, normal.

Jan. 15th till Jan. 23rd.—General condition always normal. Swelling of the eye-lid disappeared. Mouth never affected.

Fowls 22 and 23. About 6-month-old hens.

Jan. 21.—A young agar culture of the roup bacillus, isolated from fowl 3, was inoculated in the mucous membranes of the mouth and nose without any abnormal changes subsequently taking place.

Fowl 26. Healthy hen, 1 year old.

Had suffered from natural roup at the beginning of winter, but wholly recovered after being diseased for two months.

March 15.— $\frac{1}{4}$ c.c. of a young culture of the roup bacillus, isolated from an infected pigeon, was inoculated in the left superior eye-lid, and in the pleural cavity.

March 16.—General condition very much disturbed. Eyes were kept shut, left eye-lid swollen, and warm. The conjunctiva is very watery, and grey. Under the eye-lid, there is much slimy matter. The bird breathed through the beak with loud inspiratory noise.

March 17.—General condition much improved. Respiration through the beak, swelling in the eye-lid diminished. Killed by decapitation.

Post-Mortem : Carcass in a fairly well nourished condition. Conjunctiva, pale and watery. In the depth of the submucous tissue of the left eye-lid, a solid mass of grey pus, about $1\frac{1}{2}$ cm. long, is found. It can be extracted without breaking, being surrounded by a smooth brown membrane. At several places in the periorbital tissue, similar pus masses are present, but was sharply separated from the surrounding tissue. The interior eye is in tact. The nasal mucosa in the regio olfact. is highly reddened and covered with much slimy putrid secretion. In the mucous of the left lacrymal canal are small bloody extravasations. Lungs are oedematous.

Fowl No. 27. Small healthy hen, about one year old.

Had several times been inoculated with the roup bacillus without result. On the 28th of April, this bird was again inoculated with a young agar culture of the roup bacillus, which had been passed through two pigeons. $\frac{1}{4}$ c.c. was injected into each of the upper eye-lids, and 3 c.c. in the right pleural cavity.

The next day, the eye-lids were swollen, and the general condition of the fowl was disturbed. In a few days, all pathological symptoms had disappeared.

Fowl 28. Large strong hen, about $1\frac{1}{2}$ years old.

Had been diseased with roup at the beginning of the winter, and entirely recovered.

March 15.—Was inoculated with $1\frac{1}{2}$ c.c. of a 24-hour-old roup culture in the right pleural cavity, and $\frac{1}{4}$ c.c. under the conjunctiva of the right eye.

March 16.—General condition disturbed. Small swelling of the eye-lid.

March 17.—Condition, normal.

April 14.—Subcutaneously inoculated with a 5 c.c. of a culture of the roup bacillus near the sternum.

April 15.—General condition, normal. Locally no change.

April 22.—5 c.c. of a 24-hour-old roup culture again subcutaneously inoculated.

April 23.—General condition much disturbed. The bird is apathetic and mopes in a corner of the cage. Locally, no change.

May 1.—General condition still disturbed, with loss of flesh. All mucous membranes are pale; no appetite.

The 14th of June, a stinking diarrhoea set in, and the fowl died on the 18th.

Post-mortem examination showed many grey, solid nodules in both lungs, and a slimy catarrh; at other places, a hemorrhagic inflammation of the thicker bowels.

Fowl No. 29.—Young hen which had been affected with roup in the early winter; healthy when inoculated.

March 16.—Inoculated in mouth and eye-lids with a culture of the roup germ, which had been passed through pigeons.

March 17.—Eye-lids considerably swollen, and hot. On the right side there is a serous secretion from the conjunctiva. Conjunctiva is grey, swollen and soft. General condition, highly disturbed.

March 19.—In the depth of the right upper eye-lid, a solid round tumor has formed. It is neither in direct contact with the mucosa or cuticle of the eye-lid, both being movable upon it. Conjunctiva, grey-brown in color. Slimy, putrid catarrh of the conjunctiva. The left upper eye-lid is but slightly swollen, and no conjunctival catarrh exists. General condition, very much disturbed. Bird apathetic, with almost no appetite.

March 20.—The tumor in the right eye-lid is better, and symptoms of acute inflammation have disappeared. Secretion of the conjunctiva is slimy and putrid. General condition, much better.

March 21.—Dead.

Post-Mortem: Carcass fairly well nourished. The solid tumor in the right upper eye-lid consists of a firm mass of pus, 2 cm. long, $\frac{1}{2}$ cm. wide, and 2 mm. thick; color grey. It can be easily extracted, being surrounded by a dirty grey, smooth membrane. Conjunctiva is grey, and uneven. In the submucous tissue of the left upper eye-lid, there are a few grey layers of pus, not surrounded by a membrane, as in the right eye-lid. The inner eye and other organs unchanged.

Fowl No. 30. Healthy hen, about 2 years old, had been diseased with roup at the beginning of the winter; but apparently healthy when inoculated.

March 17.—Was inoculated with the solid matter (suspended in sterile water) from the eye-lid of fowl No. 26. A few drops were injected into the right upper eye-lid, 1 c.c. in the right thoracic cavity. The solid matter contained leucocytes and roup germs.

March 18.—Small swelling of the eyelid, without pathological secretion of the mucous membrane. General condition, very much disturbed.

March 20.—General condition, better. Sometimes the hen coughs. Swelling in the eye-lid mostly disappeared.

Later, the fowl recovered entirely.

Fowl No. 31. Had been diseased before. Inoculated in the same manner as fowl 30. After 24 hours, the general condition was very much disturbed, the eye-lid swollen, but the bird recovered in a few days.

Hen No. 32. Hen, gray, about one and a half years old. Had suffered with natural roup till New Year. Healthy now.

March 19.—Inoculated with a small quantity of the cheese-like matter from pigeon 12 (which had been inoculated with the roup bacillus) on the mucous membrane of the mouth and in the pleural cavity.

March 20.—General condition disturbed. A croupous membrane has formed in the mouth, about $\frac{1}{4}$ cm. in size and 1 mm. thick. It can easily be removed. The mucous membrane under it is uneven and gray.

March 26.—General condition, better. At several places in the mouth cavity, small pseudo-membranes have formed. Appetite lacking.

April 8.—Great loss of flesh. General condition, very bad. Fowl generally lies on the ground and does not care for food. Killed.

Post-Mortem: On the left side is a chronic indurative pleuritis (pleura thick and uneven, gray); liver small, spleen very large, without germs. The interior of the thin bowels contain a little food mixed with much slime. In the mucous membrane are petechial spots at many places.

Fowl No. 33.—Small hen, about 2 years old, had been diseased with roup. Was inoculated like fowl 32. Only a quickly passing disturbance of the general condition was the result.

Fowl No. 34.—Large, healthy hen that had never been diseased, about 1½ years old.

March 24.—Inoculated with agar culture (28 hours old) isolated from pigeon 20 (second passage through pigeons). The culture was rubbed in the mucous membrane of the mouth, and 1-8 c.c. was injected under the mucous membrane of the upper eye-lids.

March 25.—General condition disturbed. Hen takes no interest in its surroundings, but cowers in a corner of the cage, with the neck drawn close to body, and eyes shut. The right, upper eye-lid is considerably swollen, and has its skin reddened. Conjunctiva gray. The left upper eye-lid is slightly swollen. Mucous membrane in the mouth is pale. Several yellowish-white pseudo-membranes are located on the tongue, and the mucous membrane near it. The submucous tissue on the bottom of the mouth cavity is oedematous.

March 26.—The oedema under the tongue has increased and spread over the face, up towards the eyes. The right eye-lids are sticking together, and cannot be opened. On the mucous membrane of the pharynx are several pseudo-membranous spots. The whole mucous membrane in the mouth is covered with clots of saliva.

April 2.—General condition improved. The right eye is always kept shut, and the lids are sticking together. Beneath the eye-lid there are putrid, slimy masses, and conjunctiva is dirty gray. The upper eye-lid is much swollen, the swelling having extended especially towards the nostrils.

April 8.—Condition the same. On the conjunctiva of the right upper eye-lid, a croupous membrane is located, yellowish-white, uneven, 2-3 mm. thick, and about $\frac{1}{4}$ cm. in size. It can be removed. The mucous under it is uneven, gray and begins to bleed at several places. The oedema under the tongue has become absorbed. A small pseudo-membrane has formed on the palate near the entrance to the nasal cavity.

April 10.—General condition very bad. The fowl cowers in a corner of the cage, and pays no attention to its surroundings. It keeps its eyes shut, and the feathers are in great disorder. The appetite is very poor, and the whole face is much swollen. The wattles are swollen and prominent.

April 13.—General condition is improved. The purulent secretion from the right eye has diminished. The swelling of the face still exists. At several places fluctuation can be noticed; at others, an emphysema.

April 16.—The whole tumor is less hot, and is in an emphysematous condition. The tumors in both upper eye-lids are in communication with the tumor of the whole face. A croupous membrane still exists on the palate.

April 24.—General condition very bad. The hen lies most of the time on the floor of the cage in a comatose condition. The local changes have remained as they were, but the purulent conjunctivitis on the right side has almost entirely disappeared.

April 26.—Dead.

Post-Mortem: Carcass almost destitute of flesh and fat. Mouth and nares seemingly normal. Spleen a little swollen. In the subcutaneous tissue of the head there is a putrid abscess, the pus is dark brown, liquid, mixed with solid cheesy masses, and stinks offensively. The walls of the abscess are formed by a pyogenous membrane, which is covered with a solid layer of cheese-like, dry matter, having the appearance of the pseudo-membranes in the mouth. The rous bacillus was found in the pus, together with large numbers of coli-like bacteria. The spleen contained some coli-like bacilli.

Fowl No. 35.—Healthy hen, about one year old, which had never had rous. It was inoculated with the same culture as fowl No. 34.—two drops in the upper eye-lid of the right eye, and two drops into the high parts of the nose, the needle of the syringe being thrust through the dorsal wall of the nose.

March 24.—General condition much disturbed. Swelling of the right eye considerable, hot and firm, and the skin reddened. In the eye-lid, large quantities of slimy lacrymal secretions are present. Conjunctiva gray and swollen. Two small pseudo-membranes are located on the Conjunctiva of the upper lid.

The right nostril is covered with dirty gray, partly dried secretion. Under the tongue a croupous membrane has formed, being about $\frac{1}{4}$ cm.2 in size.

March 26.—General condition bad. The hen lies on the bottom of the cage in somnolent state ; occasionally it wakes up, rises and walks around, taking some food or water. The tumor in the right eye-lid has grown down the face as far as the wattles. It is soft and hot. The eye-lids are sticking together. By opening them, a large quantity of a purulent secretion exudes ; and a clear jelly-like mass about one c.c.m.2 in size, can be removed from the depth of the eye-lid. A pseudo-membrane, about 2-3 mm. thick, has formed on the conjunctiva at the *bulbus oculi*, just over the cornea. On removal, the mucous membrane beneath begins to bleed. The *membrana nicticans* is greatly swollen. On the interior side a pseudo-membrane has formed about 4 mm. in size. The pseudo-membrane in the mouth has increased in thickness and size. A purulent secretion exudes from the right nostril.

March 27.—General condition, better. The membrane on the *bulbus oculi* has reformed and the jelly-like mass in the lid sack has reappeared, but is now turbid and gray.

March 28.—The secretion from the nostrils smells offensively. * The right eye-lids are again sticking together, and the eye-lid contains a jelly-like, grayish mass

March 29.—General condition is very bad. The eye-lids are sticking together and bulge out, because a yellowish-white, solid cheesy mass fills the whole eye-lid. This mass has formed from the jelly-like mass, which had been removed yesterday.

April 1.—Dead.

Post-Mortem: Fairly well nourished carcass. Left eye normal. The right eye-lid diffusely swollen. Between the partly opened lids a cheesy tumor protrudes (See Fig. N. 11). It fills the whole eye-lid and can be removed by pressing on the eye-lids. The conjunctiva gray and uneven. On the upper eye-lid a small pseudo-membrane has formed ; similar membranes are located on the outside and inside of left eye-lid. Small masses of solid yellowish matter can be found in the subcutaneous tissue of the upper and lower eye-lid. The nasal cavities are blocked up with cheesy yellowish-white matter. The right infra-orbital cavity is filled up with the same cheese-like substance. On account of the pressure of this mass, the lateral bone-wall has disappeared, and the cheesy mass lies directly under the skin of the face. The mucosa of the nares is grey and very soft. The mouth contains sticky masses of saliva ; spleen and liver are small and normal. Cultures made from portions of these organs remained sterile.

Fowl No. 36. Young healthy hen.

March 24.—Was inoculated like fowl No. 35, in the nose and right eye.

March 25.—General condition is considerably disturbed. Eye-lids swollen, conjunctivitis, on the upper lid is a small croupous membrane. Nostrils are dirty. A small quantity of yellowish-white liquid can be pressed out of the right one.

March 26.—The pseudo-membrane on the eye-lid has spread upon the *bulbus*

oculi. It is about 1-2 mm. thick, and was removed. The mucous membrane under it is **grey** and uneven. Several small thin membranes have appeared near the tongue.

March 27.—The membrane in the eye has reformed. General condition improved.

April 2.—A solid, smooth tumor has formed in the depth of the right upper eye-lid. It has extended towards the nostrils.

April 15.—Chronic, putrid conjunctivitis. Eye-lids often sticking together. Croupous membranes of the Conjunctiva always reappear after removal. Small pseudo-membranes often appear in the mouth. General condition disturbed with loss of flesh. Killed.

Post-Mortem : Eye-lid contained gray, slimy masses. Mucous is uneven. A cheesy membrane, about one cm.2 in size and two to four mm. thick covers the mucosa of the upper eye-lid. (Fig. 9). It adheres firmly to the mucosa, and is directly connected with solid, cheesy matter in the depths of the eye-lid. The mucous membrane of the nares shows a few small, bloody extravasations. Other organs are normal.

Fowl No. 37. Healthy, young hen which had had roup in the early winter. Inoculated like Fowl No. 36 in the left eye. After 24 hours, the eye-lid was swollen. Later a heavy, putrid catarrh of the conjunctiva set in, and pseudo-membranes formed several times on the conjunctiva. The general condition was more or less disturbed, and the appetite normal.

April 11.—The posterior half of the cornea was covered with an irregular pseudo-membrane, about 1½ mm. thick, yellowish-white, the other half clear, with the exception of a small turbid border near the pseudo-membrane. At the same time, the conjunctival secretion smelt **offensively**.

April 12.—A great part of the pseudo-membrane had disappeared, leaving the cornea uneven and gray. Two small membranes have formed on the upper eye-lid. At the place where the cornea had been covered by the pseudo-membrane, an ulcer developed, grew deeper and deeper, and opened on the 17th of April into the anterior eye cavity. The lens fell prolapsed and grew together with the perforated cornea. The cornea wound soon became filled up with a gray granulated tumor, which regenerated slowly.

The general condition was very much disturbed, and never again became normal.

On the 1st of May, the general condition was very bad. All visible mucous membranes were very pale. The swelling in the eye-lids and the conjunctival catarrh have disappeared, but the hen was blind. Death occurred on the 4th of June.

Post-Mortem : The Post-mortem examination showed all symptoms of severe anaemia. The corpora vitrea were partly softened, the retina split in many places and portions of the retina were mixed with the liquefied corpus vitreum.

Fowl No. 38. Hen about two years old.

April 3.—Was inoculated with virulent Roup bacillus, 1-5 c.c. under the conjunctiva of the right eye, and on the scratched mucous membrane of the mouth.

April 4.—The eye-lids were inflamed, hot and sticking together. Under the eye-lid, there is much slimy lacrymal secretion, and a jelly-like mass. The places of inoculation in the mouth are covered with thin pseudo-membranes. General condition disturbed. Later on, several small croupous membranes formed on the mucous membrane in the mouth.

April 11.—The whole eye-lid was filled with a cheesy, solid mass, which could easily be removed. Conjunctiva dirty gray. On the upper eye-lid a fairly large pseudo-membrane has formed. The next day the cheesy mass had reformed larger than before.

April 24.—A large solid tumor has formed in the depth of the upper eye-lid. The pseudo-membrane could scarcely be removed. Later, the putrid conjunctival catarrh ceased, the pseudo-membrane disappeared, the tumor in the eye-lid remained unchanged. The general condition was slightly disturbed, and the hen lost flesh.

Fowl No. 39. Inoculated with a Roup culture, which had been passed twice through pigeons, but then cultivated on agar for three weeks. The eye-lids became swollen, but the swelling soon subsided. General condition remained normal. The culture, therefore, had lost most of its virulence.

Fowls No. 42-45. Healthy young hens, inoculated with freshly isolated, virulent Roup bacillus, on the mucous membrane in the mouth. Everywhere croupous membranes appeared at the places of inoculation. There they remained for a few days, and generally reappeared after removing once or twice.

The most severe reaction occurred in fowl 43 the day following the infection; the general condition was very much disturbed, the beak was kept open, and much saliva was found in the mouth. The palate was covered with a whitish croupous membrane. Other membranes were located in the pharynx.

The last pseudo-membranes disappeared in all these infected fowls in two or three weeks.

PIGEON INOCULATIONS.

Pigeon No. 1. This bird was inoculated in both eye-lids, and on the mucous membrane in the mouth, with cheesy matter taken from the wattles of diseased fowl No. 24.

Feb. 18, 1902.—The only result was a swelling of the eye-lids, which quickly disappeared.

Feb. 27.—Condition normal. Some croupous membrane taken from a diseased fowl was rubbed on the mucous membrane of the pigeon's mouth, and on the conjunctiva.

March 4.—Normal. Inoculated $\frac{1}{4}$ c.c. of a culture of the roup bacillus, which had been grown for several months on agar. The next day the bird was weak and somnolent, with no appetite. Both eyes are kept shut, the eye-lids sticking together; conjunctivitis.

April 17.—The acute conjunctivitis generally became chronic and putrid, but disappeared after a while. No pseudo-membranes formed on the conjunctiva, but several of them appeared on the mucous membrane of the mouth for several times. The general condition was better.

Inoculated 2 drops of a roup culture (24 hours old) in the left conjunctiva on the upper eye-lid, and into the mucous membrane of the mouth.

April 18.—General condition very much disturbed; eye-lids sticking together, and swollen. The lid-sack contains slimy tears. A whitish pseudo-membrane has formed on the palate. Inoculated 3 c.c. of a filtered (sterile) bouillon culture under the skin.

April 19.—Condition like yesterday. The filtered culture has been entirely absorbed.

April 28.—The chronic catarrh of the conjunctiva still exists. In the depth of the upper eye-lid, a solid tumor has formed. Good general condition.

Pigeon No. 4. This bird was inoculated on the 18th of February with cheesy masses, taken from the lungs of fowl 41 (*B. pyocyaneus*), on and in the mucous membrane of the eye and mouth.

Feb. 25.—General condition, not disturbed. The day following the infection, small croupous membranes formed at several places in the mouth. The whole palate is covered with a yellowish-white diphtheritic membrane which was difficult to remove; the mucous membrane was uneven, gray and bleeds. The eye-lids are slightly swollen.

March 6.—The pigeon is apparently normal. $\frac{1}{2}$ c.c. pure culture of the roup bacillus was inoculated into the left pleural cavity.

March 8.—General condition very badly disturbed.

March 13.—General condition has slowly improved. All mucous membranes are very pale. On the palate, a small croupous membrane has formed. Killed.

Post-Mortem: Left lung is firmly adherent to the pleura. The central part of the lung, that is, the region of the branching off of the larger bronchial tubes from the wind-pipe are solid, and inflamed. In the centre of this inflamed area is a solid, dry cheese-like, yellowish-white mass, measuring about 1 c.c. in diameter. This mass is partly surrounded with a smooth red-brown membrane. Spleen is small, and cultures made from it remained sterile.

Pigeon No. 3. Inoculated the 18th of February in the same manner as pigeon 4, and in addition 1 c.c. of the cheesy mass, triturated in sterile water, was injected in the left pleural cavity. The general condition was very much disturbed for the first 3 days after inoculation. The eye-lids were swollen, and a few small croupous membranes appeared in the mouth.

Feb. 27.—Condition normal. Some of the mucous membrane from fowl No. 27 was inoculated, after trituration in sterile water, into the mucous membrane of the eyes and mouth. No reaction followed.

March 6.—1.5 c.c. of a culture of the roup bacillus was injected into the left upper eye-lid. The eye-lid became very much swollen, and an acute serious conjunctivitis developed, and became slimy and putrid. A solid tumor formed in the swollen eye-lid. The general condition was much disturbed at the beginning and slowly became better.

May 6.—General condition normal. Local conditions have disappeared with the exception of a solid tumor in the upper eye-lid.

Pigeons No. 5, 6, 7, 10, and 11. These birds were inoculated in the mouth

and eye-lids with about 1-5 c.c. of a bouillon culture of the roup bacillus, which had been growing on artificial media for about two months. The only results were slight swelling, which generally disappeared after a few days. They were inoculated again with the roup bacillus, which had been previously passed through two pigeons. Local swelling followed the injection, with putrid, chronic catarrh of the conjunctiva, and diphtheritic membranes in the mouth.

In pigeon No. 5, on the 20th day after the infection, a bad swelling, with putrid catarrh of the nostrils, set in, and remained until death occurred. The tumor in the left upper eye-lid grew down towards the nostrils. The side of the face became very much swollen, hot and painful. After a while, the centre of the tumor became solid, and the left half of the palate began to grow down into the mouth cavity. At the lateral side of the palate, croupous membranes appeared, and always reappeared after removal. At other places in the mouth and pharynx, similar membranes appeared. The general condition of this bird was always disturbed. It lost most of its flesh, and died the 14th of April. (Second inoculation had taken place on the 9th of February).

Post-Mortem : A putrid chronic conjunctivitis is present. The tumor on the left side of the face is formed by a solid yellowish-white cheesy mass, lying just under the skin. This cheesy mass protrudes into the infra-orbital cavity, and also fills the nasal cavities. The tumor had pressed down the left part of the palate towards the mouth cavity and cause a total absorption (by pressure) of the bone at the lateral edge. Here, a thick yellowish cheese-like pseudo-membrane had formed, and this was in direct contact with the cheesy matter in the infra-orbital cavity. The lower parts of the nasal cavity contained a little putrid, slimy secretion, which had an offensive smell.

In Pigeon 6, a putrid catarrh of the nares appeared the 6th day after the second infection (19th of March). The left palate began to be pressed down towards the mouth. On the 11th day (24th of March) both nostrils were entirely closed with dried secretions, and the bird kept its beak open for breathing. The left eye was shut, the lids sticking together. On opening the lids, a putrid, slimy secretion, containing many solid, cheesy masses, could be pressed out. The anterior part of the cornea was covered with yellowish, uneven pseudo-membranes. This was removed, and the remaining cornea had the appearance of a cancer. It was soon covered again with a pseudo-membrane.

The general condition had not been very much disturbed at the beginning, but grew worse towards death, which occurred the 27th of March, that is 15 days after the second, or 39 days after the first inoculation. (See Fig. 8).

Post-Mortem : Carcass in poor condition. Nostrils and left eye are covered with dirty, offensive smelling secretions. The left conjunctival sac contains a slimy, putrid, lacrymal secretion, and a solid, cheesy mass. Conjunctiva is gray and uneven. Only a small part of the cornea, the posterior edge, has a normal appearance, the other part being covered with a pseudo-membrane, which had spread upon the surrounding conjunctiva. No turbid zone between diseased and healthy cornea exists. Under the pseudo-membrane, the cornea has the appearance of a cancer. A solid yellowish, cheesy mass was extracted from the left upper eye-lid. There was also a little tumor

under the lower eye-lid. The infra-orbital cavity is filled with cheesy matter. The palate* is pressed down towards the mouth cavity. The mucous membrane of the nares is gray and swollen. The nasal cavities are filled up with a stinking, putrid, slimy secretion. A small pseudo-membrane is located in the pharyngeal membrane. Liver is enlarged; spleen small, and contains a few coli-like bacteria.

In Pigeon No. 7 no nasal catarrh set in. The putrid secretion from the left eye smelt offensively. Conjunctival catarrh and swelling of the eye-lids had disappeared in six weeks. Inoculated a third quantity of a virulent culture, with the same severe reaction as with the second.

Pigeon No. 10 suffered from a severe putrid catarrh of the conjunctiva for two months after the inoculation. In the latter stage of the disease, severe diarrhoea set in.

Pigeon No 11 had been inoculated the second time with 1 c.c. in the pleural cavity, and with a few drops in the right upper eye-lid. General condition was very much disturbed at the beginning; later, it became better, only to become worse again. A putrid catarrh of the right conjunctiva developed, and a solid tumor formed in the depth of the upper lid. 7 days after the second infection the pigeon was dead. (23rd of March).

Post-Mortem: From the eye-lid, much solid, cheesy matter was extracted. The conjunctiva was gray and swollen; the cornea turbid, but smooth; the corpus vitreum was partly liquefied, turbid, and contained pieces of the destroyed retina; the periorbital tissue has a few gray spots of pus. The central part of the right lung is completely congested, red, and contains a small, putrid centre. The pus was liquid, with an offensive smell.

Pigeon No. 15. This case was similar to that of Pigeon No. 11. The bird died 5 days after the second inoculation.

Pigeon No. 9. Was inoculated with a virulent culture of the roup bacillus by rubbing this on the mucous membranes of the mouth and nostrils. (5th of March).

Small croupous membranes appeared in the mouth. General condition was much changed. Five days later the pigeon was killed.

Post-Mortem: The lower parts of the nasal cavity contained much putrid secretion. The left infra-orbital cell was filled up with a solid, cheesy mass. The mucosa of the nose was gray, with small blood extravasations at several places; a cheesy mass had formed, in the submucous tissue underneath the tongue. Near this place, the mucous membrane bears a small diphtheritic spot.

Pigeon No. 12. Was inoculated 14th of March with a roup culture (freshly isolated from the nares of fowl No. 23), in the mouth, nose and pleural cavity. General condition was a little disturbed the next day, when a croupous membrane formed between larynx and base of the tongue. Later on, other pseudo-membranes appeared.

March 18.—Near the left angle of the beak, a new croupous membrane has formed, and the left nostril was partly blocked up, with an offensive, gray secretion. General condition bad. The bird lies most of the time on the bottom of the cage in a somnolent condition.

March 19.—Dead.

Post-Mortem : The central part of the right lung was inflamed. This lung contained two, small pneumonic spots. All other interior organs were normal, the spleen containing but a few colon bacilli. The nasal cavities were filled up with a slimy, gray offensive secretion, which contained many cheesy masses. The left infra-orbital cavity was full of a yellow, cheesy matter, which was in direct contact with an extensive pseudo-membrane on the palate and left side of the mouth cavity.

Pigeon No. 13. Was inoculated with roup bacillus like pigeon No. 12. The general condition was disturbed. Six days after the infection, the pigeon was killed.

Post-Mortem : Nares apparently normal. Under the tongue, 2 small pseudo-membranes have formed. The submucous tissue contains a solid, cheesy mass, about as large as a hazel nut.

Pigeon No. 14. Was inoculated with a roup culture which had been growing in bouillon for 4 weeks. 1-5 c.c. was injected into the conjunctiva of the upper eye-lid and mouth. The general condition became disturbed. The eye-lids became swollen, and a solid tumor formed in it. This tumor began to get soft again after two months, and finally showed typical fluctuation. Size of the tumor, about 2 c.m.2. Two and a half months after the infection (14th of April), the pigeon was killed.

Post-Mortem : The tumor in the eye was caused by an abscess. The centre contained liquefied, putrid, gray pus. The walls were formed by a solid cheesy matter, which again was surrounded by a pyogenous membrane.

Pigeon No. 16. Was similar to pigeon No. 14.

Pigeon No. 23. Was inoculated with a virulent roup culture. The general condition was considerably disturbed. Small croupous membranes formed on the mucous membrane in the mouth. Five days after the infection (14th of April), a serous catarrh of the left nostril became apparent. Two days later, the pigeon had a very offensive smell. These symptoms disappeared after a few days, and the pigeon recovered.

RESUME OF INOCULATION EXPERIMENTS.

Reviewing our experiments with the 24 chickens, we see that to produce a typical case of roup, it was necessary to use a freshly isolated roup bacillus culture (fowl No. 3). Fowls 22 and 23 had been inoculated with the same culture grown for some time on artificial media. This caused considerable loss of virulence and failed to produce the disease.

Fowls 13, 17 and 18 were inoculated with young cultures from some of the diseased parts of naturally infected fowls. These were not pure roup cultures, and their effect upon the chickens was only a slight one. By passage through pigeons, however, the roup bacillus was made more virulent. The bacillus was usually isolated on agar or gelatine plate cultures.

The fowls 26, 28-33 were infected with a culture passed through one pigeon. These fowls had been suffering from natural roup in early winter, but at the

time of their inoculation were quite healthy. Four out of the six became diseased, while the rest showed only passing symptoms and disturbances.

A second series of experiments was carried on with roup cultures which had been passed through two pigeons. The chickens concerned in these experiments are No. 34-39 and 42-45. One of them, i.e., fowl 39, was infected with a culture which had been grown on artificial media for three weeks, after isolation from the second pigeon; in this case the bird was only very slightly affected. In all the other fowls, the cultures were used as soon as possible after isolation from the last pigeon. All reacted with pronounced symptoms comparable to those of a natural attack of roup. Two cases ended in death in five and thirty-three days respectively. Two lead to chronic loss of flesh and were anaemic. Fowl 36 was killed after a bad attack which lasted 22 days. The other diseased fowls recovered in 3 or 4 weeks.

The virulence of the roup bacillus might be made even more virulent by passage through a longer series of pigeons.

The pigeons themselves can be infected with the roup bacillus and show symptoms identical with those in chickens, but we seldom hear of pigeons suffering from roup under natural conditions, but they may become diseased as has been proven by these experiments. Very probably, they are more resistant against the natural channels of infection, being kept in relatively healthier localities than the average flock of farm chickens.

Fowl No. 27 could not be infected even with large quantities of the virulent cultures of the roup bacillus. It seemed to possess a natural immunity to roup.

Subcutaneous injections of 1-8 c.c. to $\frac{1}{4}$ c.c. cultures of the roup bacillus caused only slight disturbances of the general condition. The skin was often colored green about 24 hours after the injection, and occasionally small solid tumors (solid pus) formed. Larger quantities (2-5 c.c.) of the culture caused large tumors, which were hard and painful at the beginning; later, a hard solid, smooth or uneven, tumor formed in the depth (similar to the effect on the eye-lids), when the symptoms of acute inflammation disappeared, the solid tumor remained as a foreign body for months; and the fowl lost flesh, became thinner and thinner, anaemic, and often died in from two to six months after inoculation, or recovered very slowly. The solid tumors are nothing but a mass of solid cheesy pus (see fowl 40 and pigeon 5).

Injected into the muscles, the roup bacillus causes extended necrosis of the tissue, which smelt offensively.

In the pleura and peritoneum, putrid inflammations are produced, from which the fowls may recover, but often die after a chronic disease (anaemia) lasting from 2 to 12 weeks.

Two chickens and two pigeons were fed with cultures of the roup bacillus mixed with their food, and no bad results followed.

Fowls and pigeons once infected with roup could be infected a second time after recovery from the first attack. Birds which had suffered from a natural attack of the disease and then recovered, also became again infected by the inoculation of the Roup bacillus; and finally serum from naturally or artificially

infected birds did not show any apparent influence on the roup bacillus. In test tubes, traces of an agglutination appeared in proportions of 1:50 or 1:100. The bacillus does not form a strong toxin. Old cultures filtered through porcelain inoculated in doses of 3-6 c.c. produced no local or general disturbances.

Bouillon cultures heated to 65 degrees c. for 10 minutes and inoculated in doses of 1-4 to 1 c.c. into the eye-lids of healthy fowls produced considerable inflammation, which disappeared in 2 days. 2-5 c.c. inoculated into the pleural or peritoneal cavity disturbed the general condition for 1 to 3 days, and produced trembling of the muscles.

We attempted to immunise several fowls and rabbits with the roup bacillus, first injecting small quantities of heat killed cultures, followed by small doses of living cultures. The amount inoculated was slowly increased, but as soon as we began to use large amounts, small tumors formed beneath the skin. These became solid, hard, and had no tendency to become absorbed or to produce abscesses. They remained under the skin and led to chronic anaemia and death of the animal. After intraperitoneal injection of the cultures, the animals became chronically diseased, and grew thin and anaemic. The rabbits very often suffered with a secondary, putrid inflammation of the eyes.

These attempts to produce immunity were finally abandoned, as it seemed impossible to produce immunity by the methods described above.

EXPERIMENTS TO INFECT HEALTHY FOWLS WITH BACILLOUS PYOCYANEUS.

Fowl No. 41. Healthy hen, about 1 year old.

Jan. 12.—Was inoculated with a 24-hour-old culture of *B. pyocyaneus* which had been isolated from diseased chicken No. 19, by rubbing a little of the culture upon the mucous membrane of the eyes, and injection of 1½ c.c. into the pleural cavity.

Jan. 13.—General condition considerably disturbed. There is hot swelling of the left eye-lids, serous conjunctivitis. Conjunctiva is gray, swollen, and at several places covered with croupous membranes, which are easily removed.

Jan. 26.—General condition more or less disturbed; no appetite; putrid conjunctivitis of the left eye; the cornea is turbid, gray, and uneven; the beak is generally kept open for breathing. Mucous membrane is gray and covered with much slimy saliva.

Feb. 17.—General condition is very much disturbed. The fowl is almost a skeleton, and lies in a corner of its cage in a somnolent condition. The respiration, especially the inspiration is very irregular. Mucous membrane and crest are cyanotic. A chronic, putrid conjunctivitis exists on the left side. Cornea gray; right eye seems to be normal, but the fowl is unable to see. Killed.

Post-Mortem: Left cornea is uneven, gray, and covered with a thin, putrid mass. The corpus vitreum is turbid, partly liquefied, and mixed with parts of the destroyed retina. A solid mass of cheesy matter has formed in the pleural membrane between heart and lungs, and the surrounding membrane

is changed into a thick mass (2-3 mm.) of granulation tissue of a brown color. On the left side, all bronchial tubes in the region of the larger branches of the wind-pipe are filled with solid cheesy matter. The lungs themselves contain a few small pneumonic spots, which contain cheesy centres. The *B. Pyocyaneus* was isolated from all diseased parts. The cheesy mass itself contains nuclei of epithelial cells and a few real protozoa, motile, with short cilia (see Fig. 21.).

Fowl No. 41a. Was inoculated on the mucous membrane of the mouth and nose with the same culture as fowl 41. The next day (February 13th), the mucous membrane in the mouth was reddened, and showed a few blood-extravasations. These symptoms soon disappeared.

Fowl No. 46. Healthy, gray hen.

April 18.—Was inoculated with 1-5 c.c. of a young culture of *B. pyocyaneus* under the conjunctiva of the left upper eye-lid, and on the scratched mucous membrane of the mouth.

April 19.—General condition unchanged. Eye-lids hot, swollen, and sticking together. Conjunctival sack contains a slimy, putrid secretion. Mucous membrane in the mouth is gray and covered with slimy saliva.

April 21.—On the conjunctiva of the upper eye-lid, a pseudo-membrane has formed. It was removed, and the mucous membrane began to bleed. Several other membranes have formed on the mucous membrane near the the larynx (1-2 mm. thick).

April 25.—The condition is about the same. Putrid conjunctivitis and appearance of pseudo-membranes. The membranes around the larynx reappear after removal. A putrid secretion from the right nostril has appeared. The general condition of the fowl is much disturbed, but appetite still exists.

May 2.—Dead.

Post-Mortem : Thin carcass. Mucous membrane in the mouth pale. Between tongue and larynx a cheesy croupous membrane has formed, which is easily removed. On the edge of the larynx, a few thick pseudo-membranes have formed. The laryngeal cavity is almost filled up with pseudo-membraneous, cheese-like masses. The membranes are either located on the mucous membrane, or directly on the cartilage. The mucous membrane is entirely transformed into croupous membranes (see Fig. 10). The upper eye-lid contains a solid cheesy mass, which was attached to the surrounding pyogenous membrane by a few thin fibres. The conjunctiva of the same eye-lid is partly covered with a pseudo-membrane. The mucous membrane of the nostril is soft and covered with a putrid, slimy mass containing much solid cheesy matter. The nasal secretion has an offensive smell.

Fowl No. 47. Was inoculated on the 18th of April in the same manner as fowl No. 46. A putrid conjunctivitis formed. Diphtheritic membranes appeared in the mouth. The general condition was much disturbed at the beginning, but improved after a while. The fowl, however, grew thinner, became badly diseased again, and died the 25th of June. (See Fig. 7.)

Post-Mortem : The eye-lids were swollen, and the whole orbital cavity was filled up with a solid cheesy mass and offensive, stinking matter, the eye having disappeared.

Pigeon No. 29. The 14th of April, two drops of a young bouillon culture of *B. pyocyaneus* were injected under the conjunctiva of the left upper eye-lid. The next day the general condition was very much disturbed, the eye-lids swollen and sticking together. The eye-lids contained much slimy secretion and later two small croupous membranes had formed on the conjunctiva, the conjunctivitis became putrid, and the secretion smelt offensively. Often, pseudo-membranes appeared on the conjunctiva. A solid tumor formed in the upper eye-lid. The cornea was turbid. Subsequently, the bird recovered.

Pigeon No. 30. Was inoculated with 1 c.c. culture of *B. pyocyaneus* in the peritoneal cavity. Six hours later, it was dead.

Post-Mortem : The post-mortem examination showed an extended serous putrid peritonitis. The spleen was enlarged and cultures from this organ produced a pure culture of the inoculated bacillus.

From these few experiments with the *B. pyocyaneus*, it is apparent that this bacillus can produce chicken diphtheria in its different localizations in the mouth, eyes, nose, lungs, etc.

The virulence of the *B. pyocyaneus* is very soon lost by growing it in the ordinary culture media, but the virulence can be increased by passing it through several pigeons.

Reviewing the results of our experiments with chickens and pigeons, and comparing them with the symptoms of the natural disease, we conclude that chicken-diphtheria or roup is a complex of putrid processes, especially affecting the mucous membranes and the submucous tissues of the head. We could produce aseptic putrid processes in chickens by inoculation of sterile turpentine oil into the submucous tissue of the eye-lids, and always found the pus in the form of a solid, cheesy mass, which showed no tendency to become soft and liquid. Putrid processes in chickens seem to behave similar to those often found in rabbits, that is, the pus appears as a dry, cheesy, solid mass, not as a fluctuating abscess. (See the submucous and subcutaneous tumors in chicken-diphtheria).

In the cases of a severe putrid catarrh, the pus corpuscles often stick together, with the help of the abnormal secretion, from the mucous membranes or glands (note the jelly-like masses in the eye-lids), and finally become large, cheesy masses, which do not adhere to the diseased mucous membranes. (Cheesy masses in the nose, eye-lids, pleura, and peritoneum). In the mouth cavity, pharynx, larynx, and occasionally on the conjunctiva, the leucocytes, which passed through the mucous membranes, may remain adherent to these. Corresponding to the amount of transuded leucocytes and the degree in which the mucous membranes have been destroyed by them, or by accompanying fibrinous exudations, we observe pseudo-membranes of different severity and size.

The reason the transuded pus corpuscles remain attached to the surface of the mucous membrane in the mouth, and often in the eyes, too, but not in the nose, may be explained as follows: 1. The leucocytes have a natural tendency to stick together. 2. The described processes are very often accompanied by formation of pathological secretions (jelly-masses) in eyes and slimy

saliva, or by fibrinous exudations between the cell elements of the epithelial tissue.

These two circumstances, especially the latter, produce the formation of pseudo-membranes. The third, and perhaps most important, reason is that the mucous membranes in the nostrils possess very many mucous cells, which mix their secretion products with the transudated leucocytes, and remove these from the epithelial surface. The conjunctiva, it is true, is not without mucous cells; but they are relatively scarce. Pharynx and mouth are without mucous cells, and, therefore, pseudo-membranes easily form in these locations.

Besides the two bacilli already described as causing the chicken diphtheria, other causal agents are more or less known; thus, Loeffler described the *Bacillus diphtheriae columbarum*, Loir and Ducloux, the *Bacillus diphtheriae gallinarum* as causing diphtheria in fowls, and proved it by many experiments. Besides, there are protozoa, or corpuscles similar to protozoa claimed by other writers as the cause of fowl diphtheria.

All these results show that diphtheria in fowls cannot be a specific disease like the human one; and, from this point of view, we have to consider the pathological symptoms. For example, the fowl diphtheria in Tunis, as reported by Loir and Ducloux, is differentiated from all other forms by the very acute character of the disease; the presence of the infectious germs in all organs, secretions and excretions; and the easy infection of healthy fowls with any parts of diseased ones.

European and American fowl diphtheria is especially a chronic disease, with very variable virulence, and severity of symptoms, which partly depends on the causal agent.

Roup or fowl diphtheria is generally brought into a healthy flock by a diseased fowl from another place, a fowl having suffered from a chronic attack of the disease (the more common form may be a catarrh of the nostrils or conchae and cella infra-orbitalis) during the summer suddenly becomes very ill again during the late autumn or winter; spreads the germs of the disease and infects the flock.

The third possibility is that in unhygienic locations, fowl diphtheria may appear without any preceding attack or importation of a diseased bird, the causal organism being very ubiquitous, for example, *B. pyocyaneus*. By means of the pathological secretions, the bacilli are spread throughout the whole fowl-yard. These germs may become more virulent by passage through one fowl to another. As the appetite is not generally altered at the commencement of the disease, water and food utensils become infected with the causal organisms, and if these are sufficiently virulent, infection may take place by means of contaminated food or water; but in all cases which have come under our observation, the first symptoms of roup generally appeared after common catarrh of the mucous membranes. The roup germs, therefore, seem to be unable to invade normal mucous membranes, but become a great danger to those affected by common colds. Poultry keepers know very well how exposed chickens and other fowls are to all kinds of colds by sudden changes in

the weather. Young birds and individuals of the finer breeds are especially susceptible.

Fowl Diphtheria usually appears here with the unfavorable weather of the fall and early winter. In one night, a large number of fowls may become affected with catarrh, following which some fowls may become ropy, while others recover in a short time.

The experiments to transfer the disease by means of the pathologic secretions and excretions seems to contradict to a certain extent, our opinion about the way natural infection takes place. To explain this, we must bear in mind the fact that the causal organisms may be present in the pathologic secretions, etc., in large numbers, and in a very virulent form, whenever the germs are located on the surface, or in the highest layers of the epithelial membranes. (See fowl No. 8, and the result of isolating the bacilli from its pathologic products).

The Roup bacilli are not always localized in one place like the Klebs-Loeffler bacillus, which produces human diphtheria. The organisms causing Roup penetrate into the deeper and submucous tissues, and become the cause of phlegmonous processes and secondary catarrh of the adjacent mucous membranes and glands. In such cases, the roup bacilli are seldom present in the slimy, putrid secretions and pseudo-membranes. Further, the roup bacilli have often entirely disappeared from the pathologic secretions, or are mixed with many other bacterial species. This phenomenon occurs not only in chronic cases of natural infection, but also takes place in fowls which have been inoculated with the roup bacillus.

The pathological products themselves are sufficient, owing to their localization, their consistency, and the histological changes they cause, to produce the continuance of chronic catarrhs. Finally, as already stated the roup bacilli, enclosed in the cheesy masses, lose their vitality.

The fowls experimented with did not suffer from common colds, which must play an important part in the natural disease. As our experiments show, it is easier to infect healthy birds by keeping them a long time with diseased ones (5 out of 10 became diseased) than by direct inoculation of pathologic products on the experimental animals. The explanation of this is that fowls kept with diseased ones for a long time, are exposed to the possibilities of an infection, and at some time during this exposure the natural resistance of the bird is lowered, or some unfavorable condition allows infection to occur.

REFERENCES.

- Babes und Puscariu, Zeitschrift fuer Hygiene, Bd. 8. 1890, S. 376.
 Bollinger, Virchow's Archiv, Bd. 58. S. 349.
 Brown, Poultry-Keeping, 1901. p. 109.
 Chicoli, Sicilia agricola, 1884.
 Cornil u. Megnin, Revue d'hygiene, 1884. S. 850.
 Cornevin u. Nicati, Journal de medecine veterinaire, Lyon, 1879.
 Corbett, The Poultry Yard and Market, New York, 1877. p. 88.
 Dickson, Poultry: Their Breeding, Rearing, Diseases and General Management, London, p. 221.
 Eberlein, Monatshefte fuer praktische Tierheilkunde, Bd. 5. 1895. S. 433.
 Emmerich Revue d'hygiene, 1884. p. 850.
 Ernst, Zeitschrift fuer Hygiene, 1888.
 Ferre, Arch. clin. de Bordeaux, Bd. 6, 1877, p. 275. Nach Baumgartner's Jahresberichten.
 Friedberger, Deutsche Zeitschrift fuer Tiermedizin u. vergleichende Pathologie, 1879. S. 161.
 Friedberger u. Froehner, Lehrbuch der speziellen Pathologie u. Therapie der Haustiere, Bd. 2, 1900. S. 467.
 Gallez, Deutsche mediz, Wochenschrift, 1896, Nr. 49.
 Galli-Valerio, Centralblatt fuer Bakteriologie, etc., Bd. 22. 1897. S. 500.
 Guerin, Annales de L'Institut Pasteur, 1901, Nr. 12. p. 941.
 Johne, Bericht ueber das Veterinaerwesen in Koenigreiche Sachsen, 1880.
 Konhaeuser, Monatschrift des Vereines Oestreichischer Tieraerzte, 1878.
 Kitt, Bakterienkunde, u. pathologische Mikroskopie Wien, 1899. p. 180 und 410.
 Krajewsky, Deutsche Zeitschrift fuer Tiermedizin und verleichende Pathologie, Bd. 13, 1887. S. 311.
 Loeffler, Mittheilungen aus dem kaiserlichen Gesundheitsamt, Bd. 2, 1884. S. 482.
 Loir u. Ducloux, Annales de L'Inst. Pasteur, 1894. p. 599.
 MasFadyean & Hewlett, the British Medical Journal, London, 1899, 2, p. 1357.
 Mazzanti, Osservazioni clinico-sperimentali sulla pseudo difterite da cercomonadi. Parma, 1896.
 Moore, Investigations concerning infectious diseases among Poultry, Washington, 1895, p. 39.
 Dawson, Annual Report of the United States Department of Agriculture, Washington, 1898, p. 352.
 Neumann, Archiv fuer Kinderkrankheiten, Stuttgart, 1890.
 Penzoldt, Deutsches Archiv fuer klinische Medizin, Bd. 42, 1887.
 Perroncito, II Medico veterinario, 1886, p. 249.
 Piana Galli-Valerio, Moderno Zooiatro, 1894.
 Puetz, Oestreichische Zeitschrift fuer Vet. Wissenschaften, Bd. 1, 1887.

- Pfeiffer, Zeitschrift fuer Hygiene, Bd. 5. 1889, S. 363.
 Robinson, Poultry Craft, Boston, 1899.
 Rivolta, II Medico veterinario, 1869.
 Rivolta u. Silvestrini, Giornale di anatomia, fisiologia e patologia, 1873,
 p. 42.
 Rivolta u. Delprato, L'ornitologia, Pisa, 1880, p. 271.
 Rivolta, Dei parassiti, veget., Torino, 1873.
 Siedamgrotzky, Bericht ueber das Vet. Wesen im Koenigreiche Sachsen,
 1872. S. 87.
 Stevenson, Journal of Comp. Med. 1898, July.
 Theobald, The parasitic diseases of Poultry, London, 1897.
 Trasbot, Annales de med. veterinaire, 1879, p. 465.
 Trinchera, Clinica veterinaria, 1899.
 Whitfield, The Indian game fowl, London, 1892.
 Williams u. Cameron, The Journal of Pathology and Bacteriology, Edinburgh and London, 1896, 3, p. 344.
 Wright, The practical Poultry Keeper, London, Paris, Melbourne 1897.
 Zuern, Die Krankheiten des Hausgefluegels, Leipzig, 1882, p. 104.
-

Ontario Agricultural College and Experimental Farm

THE PRESENT CONDITION OF THE SAN JOSE SCALE IN ONTARIO.

BY WM. LOCHHEAD, B.A., M.S., PROFESSOR OF BIOLOGY AND GEOLOGY.

It is now nearly ten years since the San Jose scale made its appearance in the United States east of the Rockies, and it is about seven years since it first appeared in Ontario. It has made progress in that time in spite of all the efforts which have been put forth to keep it under control. In the St. Catharines district there are but few orchards which have escaped invasion, and many have succumbed to the terrible attack. In the West the scale is very prevalent in South Essex and Kent. Although the scale is so widespread in these districts, yet we must remember that if it had not been for the energetic action of the Government in appointing inspectors, and in passing the Fumigation Act for the treatment of nursery stock, in my judgment, the scale would have spread to most parts of the Province.

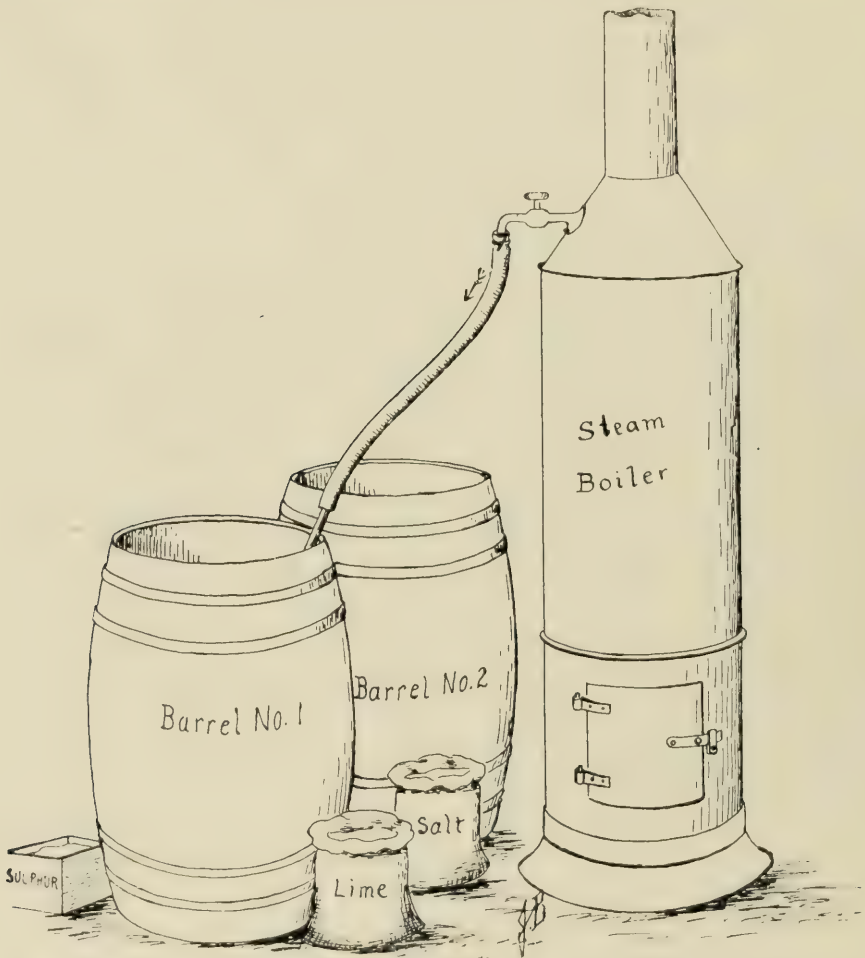
Never before has the San Jose scale problem seemed so easy of solution as it does to-day. After long experimentation we now know that we have methods which are both effective and easy to apply. The whole solution of the difficulty lies now with the fruit grower himself. There are five more or less effective remedies—first, the lime, sulphur, and salt mixture; second, crude petroleum; third, crude petroleum and whale-oil soap emulsion; fourth, whale-oil soap solution; fifth, the McBain Carbolic Wash. With regard to the lime, sulphur, and salt mixture, its effectiveness was demonstrated beyond doubt by Mr. G. E. Fisher, and it is being extensively used, in the West particularly, as an effective remedy. The chief points of excellence of this mixture are: First, its cheapness; second, its effectiveness; third, its cleansing effect upon the tree from both insect and fungous pests. The fact that it is somewhat difficult to prepare and hard on the men and apparatus, has made this mixture unpopular with some of our fruit growers. Where the fruit grower has the proper appliances for making the mixture its operation is not so difficult as it appears.

The crude petroleum is well adapted in the West for apple treatment, and in the Chatham district I fail to hear of the death of a single tree. In that district the oil is easy to procure and the fruit growers are well pleased with the results. The objections which have been urged against crude petroleum are: (1) The great variation in strength of the oil; (2) The disagreeableness of application, and (3) The great liability of its injuring plums and peaches.

The emulsion of crude petroleum and whale-oil soap, although a very effective remedy, has never taken well with the fruit growers, on account of the difficulty which was found in making the emulsion, and of the disagreeableness of the application.

Whale-oil soap solution, although quite effective when properly applied, proved too expensive for the average orchard, and has been given up.

The McBain Carbolic Wash is a new insecticide which has been tried for the first time in Canada this summer and has given good satisfaction wherever it has been tried. Further experiments are necessary, however, to determine if the winter applications of the Carbolic Wash will prove as successful as the summer applications.



W. W. Hilborn's appliance for making the lime-sulphur-salt mixture.

The lime, sulphur, and salt treatment, which the Essex fruit growers are using quite freely, is extremely cheap. Mr. J. D. Wigle, of Kingsville, tells me that it cost him but ten dollars for outside help to spray forty apple trees and eight hundred peach trees with this mixture. Mr. W. W. Hilborn, of Leamington, is also quite enthusiastic over the mixture. He had some hesitation last spring in using it, but when he came to prepare it he found it much simpler than he had expected. He used a boiler, which he procured for ten dollars, to supply the steam for boiling the mixture. He used the 15, 15, 10 formula. The lime he slaked slowly in a coal-oil barrel with four gallons of water; then the sifted sulphur was added with stirring to the hot mixture,

and the whole boiled for an hour; then the salt was added and the mixture boiled for half an hour longer. Mr. Hilborn kept a second barrel of hot water always convenient. This mixture was very effective, and I failed to find a single scale at the time of my visit, August 27th. It was applied also against the Scuriy Bark Louse and the Oyster Shell Bark Louse, and the results were extremely satisfactory. The Township of Gosfield, in which Kingsville is situated, passed a by-law last spring compelling treatment of infested orchards, and a township sprayer, Mr. H. Bruner, was appointed to do the work whenever the owner himself cared not to spray. The results were quite satisfactory to most of the fruit growers, and they now see the solution of this problem of the San Jose scale.

In the St. Catharines district, however, the lime, sulphur, and salt treatment has not become popular, but no one seems to doubt its effectiveness against the scale.



PLATE 1. The Kottmeier orchard of about 400 plum-trees at St. Catharines treated with the McBain Carbolic Wash. (Pho. Aug. 14, 1903).

Mr. G. A. McBain has had a very interesting experiment under way, testing the effectiveness of his "Carbolic Wash" (Plate 1.). He undertook to clean up the Henry Kottmeier orchard, which contains about four hundred trees, mostly plums of five years' growth. Mr. McBain has given the orchard three applications. The first was made with his winter wash on the 28th and 29th of April, the second with his summer wash on the 14th and 15th of



PLATE 2. A peach orchard near St. Catharines practically destroyed by the San José Scale, containing 10,000 trees, now neglected and left untreated. (Photo. Aug. 14, 1903.)

July, and the third with the summer wash on the 14th and 15th of August. The winter application, although fairly satisfactory, did not kill all the scale, but as large a percentage as one could naturally expect from the encrusted condition of the trees. Besides, Mr. McBain tells me that he could now guarantee a much larger percentage of scale killed, because he was afraid to use a stronger formula than the one he had been using in California. I examined the orchard on the 14th of August, before the third application, and found but few scale on the trees. The trees looked healthy and had made a decided growth. Some of the leaves of the trees had been singed by the summer mixture, but I think no appreciable damage would be done.

There are two preparations made by Mr. McBain under the name of Carbolic Wash—the Winter and the Summer preparations. The Winter Wash was used in the first spraying operations and against the aphids. The Summer Wash is, in my judgment, the more effective scale remedy. It is not so black and does not contain so much crude carbolic acid as the winter wash. It remains to be seen how effective the Summer wash will be when applied in the winter, as Mr. McBain intends doing in future.

The McBain Carbolic Wash has been in use for some years in California as a scale remedy. It is a black, oily liquid, and smells strongly of crude carbolic acid. Other ingredients are pine tar and fish oil. The strong point in favor of this wash is the readiness and ease with which the spraying liquid can be prepared. When a barrel of liquid is to be made up, two or three gallons of the black carbolic wash are placed in the barrel and cold water added. The wash dissolves very readily, and the barrel of liquid has a milky appearance. Another feature of the preparation is that its application by the spray pump is not an unpleasant operation. The operator does not need a special suit of old clothes, as he would if he were spraying crude petroleum, whale-oil soap, or the lime, sulphur and salt mixture.

In my judgment the points of the McBain Carbolic Wash which I have indicated are very important ones in future operations against the San Jose Scale, for experience proves that the ordinary fruit grower is influenced mightily by the character of the spraying operation. I believe that the main reason why the crude petroleum, and the other preparations which are effective against the scale, did not take with the people was this very factor—the disagreeable nature of the spraying. As we all know, a perfect insecticide must possess the following qualities:—

1. It must be effective against the insect; 2. It must not harm the plant;
3. It must be readily and easily applied; 4. It must be cheap.

From my observations this McBain Carbolic Wash possesses at least three of these qualities, and it may have the fourth also, for I do not know what the retail price of it will be. This is an important point, but if the manufacture of the substance is to be made a business matter, then I have not much fear on this point.

In addition there is ground for the belief that this wash is valuable not only for controlling the aphids of apple, plum and cherry, but also as a fungicide for peach-leaf curl, apple scab, and the brown rot of plum, when used at the rate of 1 to 30.

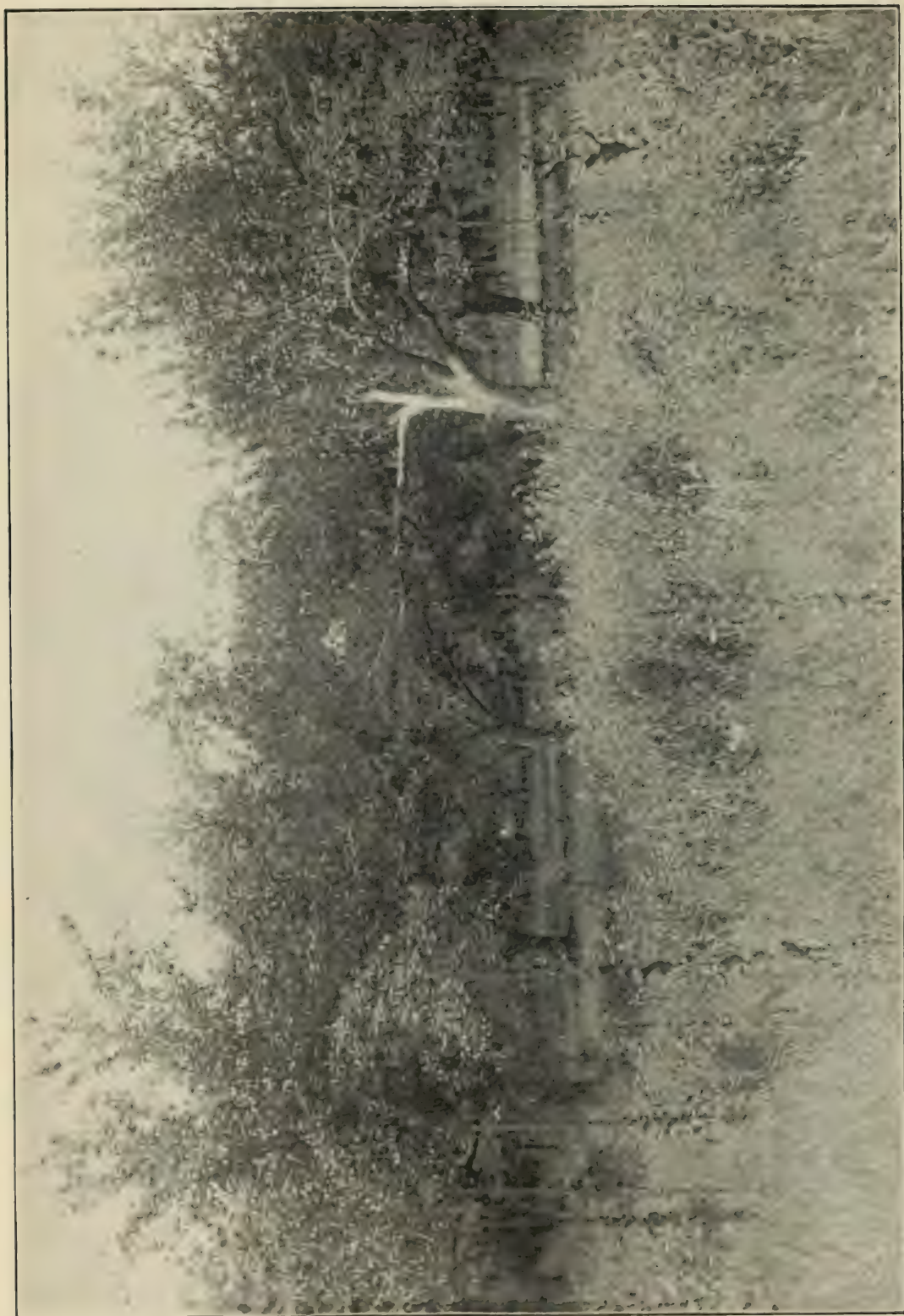


PLATE 3. A large apple orchard near Kingsville very badly encrusted with San Jose Scale. The owner refused to treat the orchard himself, or to allow the township sprayer to do it for him. This orchard is now a menace to the neighboring ones. (Photo, Aug. 27, 1903.)



PLATE 4. An apple orchard belonging to John D. Wigle, Kingsville, sprayed with lime, sulphur and salt in early spring. Very few scales could be found at time of visit. (Aug. 27, 1903.)

Now as to the future of the San Jose Scale. I do not advocate that the Provincial Government should continue to lay out large sums of money every year in fighting the scale. They might with just as good reason be asked to spend money in fighting the Potato Beetle, the Codling Moth, or the Hessian Fly. The Government, I maintain, has done its duty with regard to the scale; and now that reliable, efficient remedies are known, the matter of controlling the pest must remain with the fruit growers. I am sure that the Government is willing to assist the fruit growers with advice and even with help when necessary.

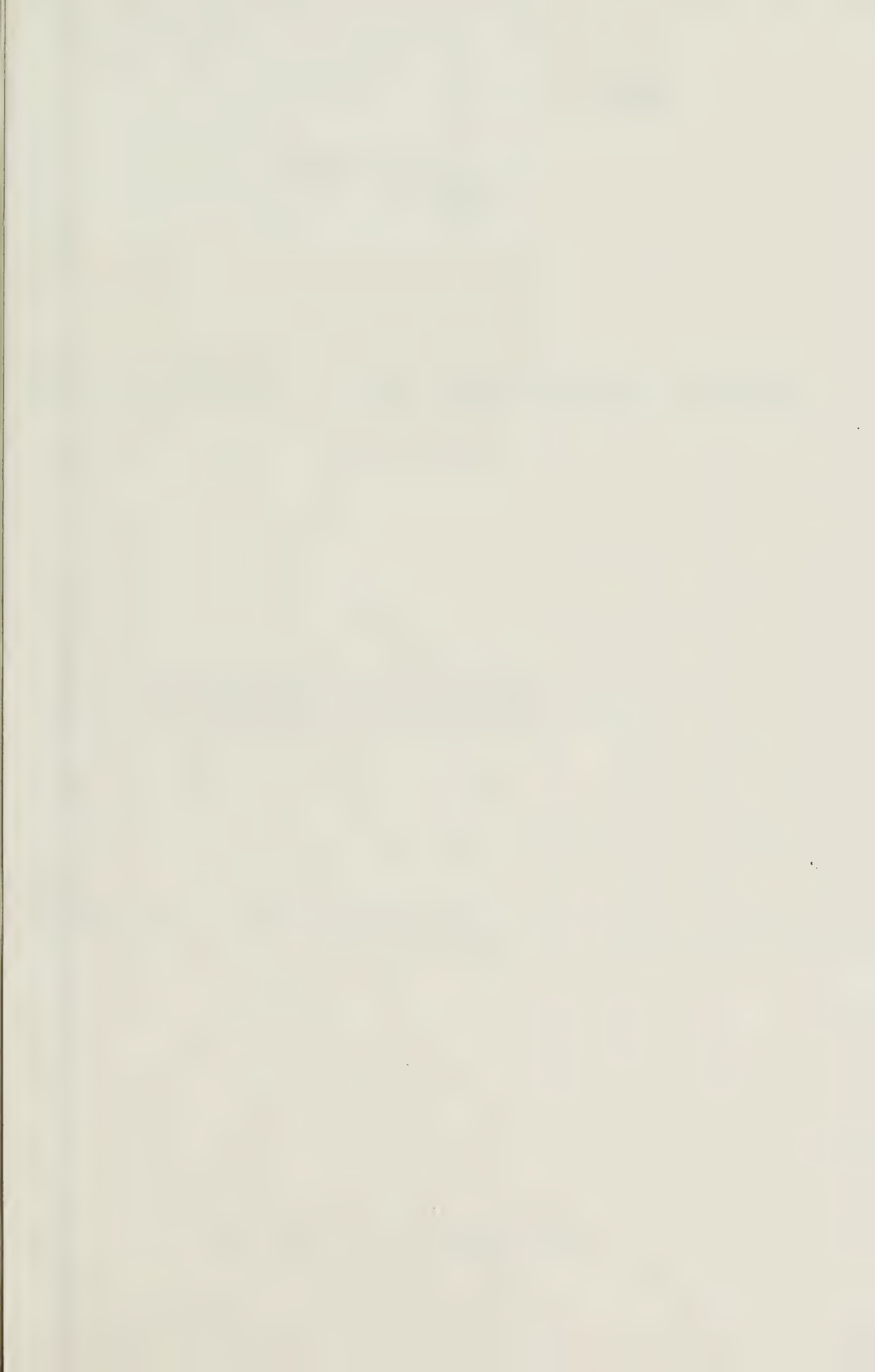
This help should come in the form of reduction of cost of chemicals, as has been given in previous years, and in establishing a system of Township Sprayers under Governmental supervision, perhaps. To my mind the greatest need at the present time is not a new remedy, for we have efficient ones already, but an organized system of sprayers by whom every orchard can be sprayed at a reasonable cost at the proper time, and in the proper manner. Many of our smaller fruit growers have neither the outfit for doing good work, nor the time and help to spray at the proper season. They would be perfectly willing, however, to pay for the spraying of the orchards by a reliable party. In Gosfield Township, Essex County, a township sprayer was appointed last spring, and so far as I could learn from inquiries in the vicinity, the fruit growers are thoroughly satisfied with the results. A prominent grower told me that he no longer feared the scale, so long as he could get his orchard sprayed with the lime, sulphur and salt mixture, and by reliable sprayers at a reasonable cost. (See Plate 4.) A St. Catharines fruit grower thinks the McBain Carbolic Wash solves the difficulty in regard to keeping the scale in check. He thinks that there will now be no difficulty in finding good sprayers to do the work, since the wash is not disagreeable to use. He said that his own men looked upon the spraying operations with crude oil, or the whale-oil soap as a veritable ordeal.

There is another matter in regard to the scale which should be attended to as soon as possible. In the scale-infested sections there are orchards which are never sprayed. As a result they are neglected, and they form veritable breeding grounds for the scale, and other pests. I know of several orchards which are thus neglected. (Plates 2 and 3.). It is not fair to the other fruit growers that they should be exposed to such conditions.

The townships should see to it, and pass a by-law compelling the spraying of the neglected orchards, or to have them cut down and burned. The Government might very reasonably look after the inspection necessary for the proper carrying out of the by-law. We all know how such a by-law would soon become a dead letter through difficulty in getting the local authorities to carry out its provisions. An outsider can carry on the work, but a local man cannot.

Furthermore, fruit growers must recognize the necessity for at least one spraying every year. In badly infested orchards two sprayings should be made.

Finally, good spraying outfits,—a 5-ply hose—not an ordinary garden hose, should be used.



018670001

N.F.T.



